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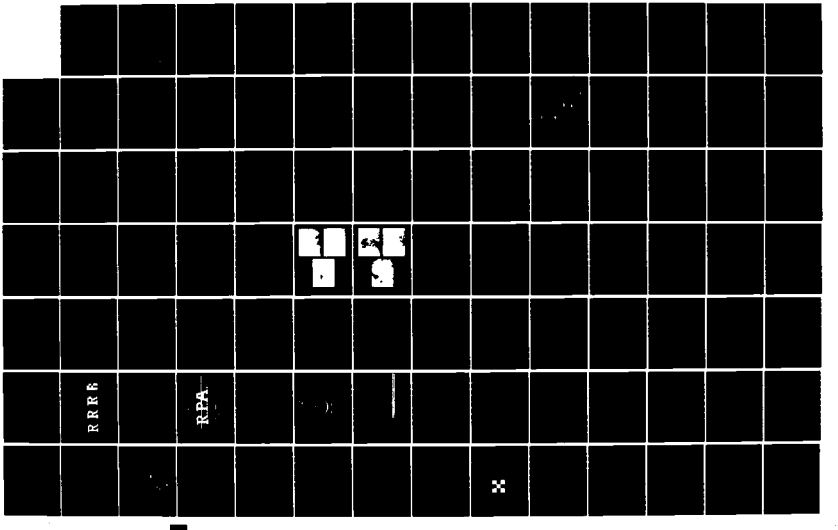

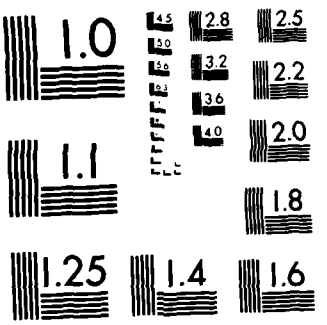

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DEPARTMENT OF THE ARMY

Official Military Personnel Files (OMPF)

Micrographics System Study

Contract No. MDA903-83-C-0490

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Austin Associates

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Contractor: Austin Associates
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FINAL REPORT

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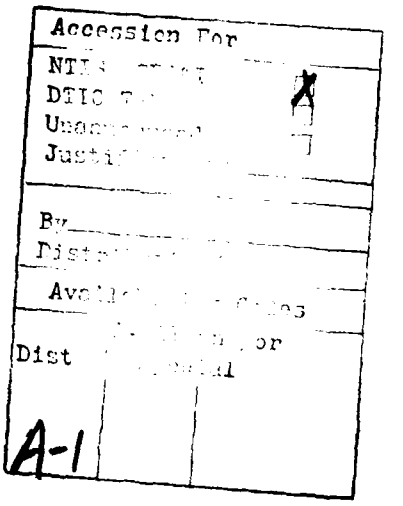

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This study was an evaluation of the Department of the Army, Official Military Personnel File (OMPF), an A.B. Dick System 200 updatable microfiche system, with Access-M retrieval equipment. This study included evaluation of the systems at MILPERCEN, EREC, RCPAC, NGB and NPRC. The study includes evaluation of each center and recommendations for improvement of the existing micorgraphics systems, and recommendations for conversion to a digital imagery system to take advantage of the state of the art of emerging technology for the 1985-1990 timeframe.

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FOREWORD

The Department of the Army began conversion of the Official Military Personnel File (OMPF) from paper to microfiche in 1976 based upon the findings of the RAM2 (Records Administration in Microform Mode) Task Force. After an evaluation of problems with the paper filing system, a review of alternative micrographics systems, and a review of systems developed by the Navy and the Air Force, the RAM2 Task Force recommended conversion to the A.B. Dick System 200 updatable microfiche system with Access-M retrieval equipment. At this time, the microfiche system is operational at the four Army personnel facilities: Military Personnel Center (MILPERCEN), Enlisted Records and Evaluations Center (EREC), Reserve Component Personnel Administration Center (RCPAC), and the National Guard Bureau (NGB). Conversion has not yet been completed, however, at the latter two sites.

In June 1983, the Department of the Army, Defense Supply Service, issued a request for proposal to meet the following objective:

> Conduct a study to develop alternatives for the 1985-1990 timeframe that would permit MILPERCEN and the Army's current micrographics operations to adjust to or be replaced by emerging technology.

In September 1983, Austin Associates (Englewood, CO), a records and information management consulting firm, was selected to conduct this evaluation and project work began in October 1983.

The project was scheduled to be completed in 120 days, but was extended to 125 days by the Project Committee due to delays in constituting the first Project Committee meeting. During the course of the project, the following tasks were completed by Austin Associates:

- Interviews were conducted with managers and operational staff at MILPERCEN (Alexandria, VA), EREC (Indianapolis, IN), RCPAC (St. Louis, MO), NGB (Arlington, VA), and National Personnel Records Center (NPRC-St. Louis, MO). Interviews were also conducted with representatives from the Department of the Navy, Air Force, and Marines, to review systems developed for their military personnel records. Finally, a number of interviews were conducted with vendors, consultants, and systems integrators involved in the areas of micrographics and digital image technology. Appendix A contains a list of individuals interviewed; Appendix B contains a list of vendors contacted during the course of the project.

- Alternative technologies were reviewed which might be considered to replace the existing OMPF microfiche system. Besides interviews with vendors, the Project Staff participated in demonstrations and trade shows, and reviewed available technical literature to obtain detailed information on system performance and capabilities.

- The Project Staff conducted a series of briefings for the Project Committee to review findings and problems related to each aspect of this project. The briefing schedule was as follows:

- Briefing No. 1 (October 11, 1983): Review of project scope, activities, and modifications.

- Briefing No. 2 (November 8, 1983): Evaluation of existing micrographics system.

- Briefing No. 3 (November 22, 1983): Review of alternative micrographic-based systems and recommended improvements to the existing microfiche system.

- Briefing No. 4 (December 6, 1983): Review of transition of microfilm-based systems (microfilm storage with digital image transmission) and digital image technology.

- Briefing No. 5 (January 11, 1984): Review of draft final report.

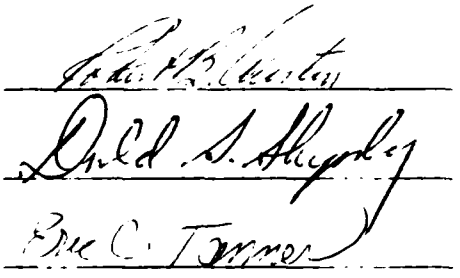
- This project report was prepared to document the findings and problems related to this project. This report has been reviewed by the Project Committee and revised as necessary. The report reflects the views of Austin Associates and does not necessarily represent the policy nor the position of the Department of the Army.

Throughout the course of this project, the Project Staff worked closely with the Project Committee selected to represent the Department of the Army. The Project Committee consisted of the following individuals:

LTC Gerald V. Turcotte, MSD, MILPERCEN
Odis Mays, EREC
John Slazinik, Jr., RCPAC
CW4 Webster Rose, NGB
Joseph G. Hardy, TAG
Roy S. Brandon, OCAR, Automation Management-Pentagon
Robert Barrow, PERSINSD, MILPERCEN

We wish to extend our sincere appreciation to the members of the Project Committee who provided extremely valuable information and insights which enabled the Project Staff to more fully understand the existing operation and problems. The quality of this report is due, in part, to the cooperation received from the Project Committee in completing the tasks required.

We would like to thank Barbara Durland, Affiliated Executive Systems, for her patience and conscientiousness in typing this report, and Arlene Motz, Janet Whitehead and Daniel Woodward for reviewing this report.



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EXECUTIVE SUMMARY

This project reviewed and evaluated the Army's Official Military Personnel File (OMPF) micrographics system at the Military Personnel Center (MILPERCEN-Alexandria, VA), Enlisted Records and Evaluation Center (EREC-Indianapolis, IN), Reserve Component Personnel Administration Center (RCPAC-St. Louis, MO), the National Guard Bureau (Arlington, VA), and the National Personnel Records Center (NPRC-St. Louis, MO). Alternative systems were considered for future development, including the micrographics-based transition technologies and the new digital image technology. The findings and conclusions of this project have been extracted from the full report and are summarized by chapter below.

CHAPTER 1. OVERVIEW OF EXISTING OMPF MICROGRAPHICS SYSTEM

The OMPF is the official Army record of service, performance, commendations, decorations and disciplinary action. During the early 1970s, the Army OMPF were maintained in paper format, resulting in a significant number of problems: large space requirements, difficulty maintaining file integrity, no system backup, large staff requirements, and substantial time requirements to assemble records for Boards. The Records Administration in Microform Mode (RAM2) Task Force was formed to review the personnel records system. After the Task Force evaluated problems with the paper filing system, alternative micrographic technologies, and systems developed by the Navy and the Air Force, the RAM2 Task Force selected a system consisting of the A.B. Dick System 200 updatable microfiche system with Access-M retrieval equipment. This system is now operational at the four personnel facilities; although conversion is still taking place at RCPAC and the National Guard.

The review and analysis of each personnel facility indicated general satisfaction with the microfilm system, although a number of significant problems were evident.

CHAPTER 2. EVALUATION OF EXISTING OMPF MICROGRAPHICS SYSTEM

A questionnaire was developed in order to determine the system evaluation criteria, weights to be assigned to each criterion, and the appropriate score for rating each criterion. The following are system selection criteria groups presented in order of importance:

- Image quality
- Security
- Integrity
- Reliability/maintenance
- Image creation/management
- System development
- Dissemination/use
- Personnel
- Cost
- Environment

A second questionnaire was prepared and completed by 116 Board members, including some from each of the four sites. Due to the importance of Boards

and the responsibility of the individuals involved, the conclusions from this questionnaire are particularly significant:

- Most Board members prefer the microfiche to the paper records.
- Blacked-out images on the microfiche may be considered by a significant number of Board members in evaluating a record.
- Filming errors on the microfiche slow down the review of most Board members.
- Most Board members believe some information included on the microfiche, especially letters of appreciation, are useless for the evaluation.
- Most Board members indicated that their eyes are tired after reviewing the microfiche records all day.
- A significant number of Board members indicated that they would prefer a paper photograph rather than a microfilm image of the photograph.
- Many Board members in the comments expressed concern regarding quality of the images produced in the system.

While a number of significant problems exist in the system, the existing OMPF microfiche system must receive a good overall evaluation. Some positive conclusions related to the system are as follows:

- The decision of the RAM2 Committee to convert to an updatable microfiche with automated retrieval equipment was correct.
- The existing microfiche system performs better than the previous paper system.
- The microfiche system meets the Army's needs.
- The microfiche system will enable the Army to function during the timeframe 1985-1990, but problems will continue to exist over that period.
- While the original microfiche cannot be used in future system development, the original can be converted into a new format for use with new systems developed.

A number of problems were detected in the system for which no solutions were discovered. These problems cause severe difficulty with system operation and have an apparent negative impact on the use of OMPF information, especially by the Boards. The following problems represent the primary reasons why the Army should convert to another image processing system by the late 1980s:

- Inability to erase and resequence images.
- Degradation of the updating capabilities of the original updatable microfiche.

- Slow system speed for filming and retrieval.

- Inability of system to adequately reproduce photographs.

- Lack of access to the original microfiche during update and duplication.

- Duplication required for distribution of information.

- Human intervention required at each stage of the process.

CHAPTER 3. MICROGRAPHICS TECHNOLOGY ISSUES RELATED TO EXISTING SYSTEM

The A.B. Dick System 200 updatable microfiche was selected for the OMPF primarily because all images related to a personnel record could be maintained together, the ease of adding additional images to the microfiche, and the simplicity of production. Many of the major problems with the existing system described above, are attributable to the updatable microfiche technology.

An extremely large number of duplicate microfiche are made annually at all four sites. Since users access the OMPF only through duplicate copies, the quality of these copies is extremely important for the success of the entire OMPF system. Some recommendations related to duplication are as follows:

- An inspection and quality control program should be developed for microfiche duplicates.

- The temperature on the duplicators should be set to approximately 170°F to create the best quality duplicate image.

- Duplicator operators should wear cotton gloves to protect the original microfiche.

- An experiment should be conducted with the Boards using vesicular duplicate film to determine whether a negative image will reduce eye strain and fatigue compared to the current positive duplicates.

Some users, especially Boards, spend a great deal of time reading microfiche. Consequently the microfiche readers provided to users should be of the highest quality and provide features to facilitate use.

An ergonomic work station should be provided, especially for Boards, since they utilize the microfiche for long periods of time. Some characteristics of an ergonomic work station include adjustable chairs, adjustable reader height, tilt and swivel capabilities for readers, and adjustable desk height.

Most paper prints produced by reader-printers were extremely poor. Since only a few reader-printers are required in the system, it is suggested that high quality reader-printers be obtained in order to provide high quality paper prints when necessary.

Each installation maintains a computer system to identify the Access-M number for each record and to perform other tasks. The retrieval process may be

enhanced through the addition of computer-assisted retrieval of the Access-M units and addition of the Automatic Delivery System for automatic ejection of a carrier from a cartridge.

CHAPTER 4. ALTERNATIVE MICROGRAPHICS SYSTEMS

Since the RAM2 report in 1975, a number of vendors have developed advanced micrographics systems, some including the capability of digitizing micrographic images and transmitting them electronically. These systems are distinguished by the method of file organization (either unit record or random access), method of retrieval (method used to locate the particular roll of microfiche and the methods used to locate the specific image), and method of image presentation (either optical projection or display of digitized image). The microfilm systems now being marketed can be classified as follows: manual microfilm system, computer-assisted retrieval (CAR) systems, automated document storage and retrieval system (ADSTAR), and automated document storage and retrieval systems plus digitized image transmission (ADSTAR+DIT).

None of the micrographic-based technologies reviewed warrant serious consideration to replace the Army OMPF updatable microfiche system.

CHAPTER 5. DIGITAL IMAGE TECHNOLOGY

During the last few years, much has been written and discussed regarding the process of the "electronic filing system." A number of vendors have developed systems which they call "electronic," but in reality prove to be microfilm storage systems with computer-assisted indexing and retrieval. Beginning in approximately 1982, significant developments occurred which marked the emergence of the still infant technology now referred to as "digital image technology." In 1983, vendors began offering scanning equipment and appropriate computer software to automate the digitizing process. In addition, the first commercially available optical disk systems were marketed and a number of prototypes demonstrated. During the next few years, it is expected that a number of pilot projects and operational systems using digital image technology will be developed to meet pressing needs of both government and industry.

With the recommended enhancement of the existing OMPF microfiche system, the Army can wait a few years before converting to this new technology. During this waiting period, however, the problems with the existing updatable microfiche system will continue to grow. A pilot project should therefore be developed as soon as possible, followed by the conversion to operational systems for all Army personnel records.

A digital image system consists of five components: image capture, storage/optical disk, image transmission, image presentation, and the computer system. Most scanners use charge coupled devices (CCD) to provide high scanning speed, good resolution, and flexibility in operation. The scanner examines the image in terms of discrete points (or pixels), and converts this information into binary format for computer storage. Although most systems can recognize differences in gray scale for documents, much more storage is required. A resolution of 300 dots/inch will capture finer detail (but require more storage space) and has been used in the report; a resolution of 200 dots/inch may be adequate.

The emergence of optical disk technology has supported the development of digital image systems. Optical disk is capable of storing 40,000 to 100,000 documents, depending on the type used. Vendors are now developing juke box devices which can store 100 or more disks, enabling the on-line storage of millions of documents per juke box. Optical disk offers high storage capacity, automatic verification of information writ.n, long life, and rapid access to information (in milliseconds). While optical disks now cost $100 to $200 per disk, it is expected the price will be lowered to $40 to $75 per disk within two years.

Once the image has been scanned and stored, the image can then be electronically transmitted to users to perform their daily activities. Due to the volume of digital information (or bits) required to form an image, the transmission speed is extremely important for the effective operation of the system. The Army is currently developing a local area network for MILPERCEN and enhancing the Defense Data Network. Unfortunately, the systems are designed for data, rather than images, and a maximum transmission rate of 56,000 bits/second is planned. At this rate, it would require almost 12.5 minutes to transmit a single 50-page record. Fiber optics offers significant improvement in data transmission images, enabling a 50-page record to be transmitted in less than one second.

The image can be presented to users in one of three forms: high resolution graphics display terminal, printer output, or microfiche developed from a modified computer output (COM) unit. Due to the high cost of high resolution graphic terminals, it is expected that only a limited number will be used during the first years of operation. Most output will be provided to users in microfiche form, produced from the digital image using a COM unit.

The computer system selected to handle the digital image technology must have extremely fast input/output speeds, high capacity memory, and substantial magnetic disk storage (for indexing). The system software will be required to handle image capture, communications, backup, transfer of information, purging, scheduling, and special features such as character recognition and forms overlay capabilities.

The digital image system operates substantially different than the existing OMPF microfiche system, resulting in only a few procedural stages:

- Documents are received and screened.
- Documents are scanned.
- Digitized images are stored on a daily optical disk.
- Images are indexed and enhanced as necessary.
- Final images are stored on optical disks in juke boxes.
- Documents are destroyed.
- Images are then transmitted to users through output from high resolution graphic terminals, printers, or COM units.

Since digital image technology is in its infancy, a number of special issues must be addressed before the Army can fully proceed in developing a comprehensive digital image system. The legal status of digitized images, especially signatures, have never been determined in an actual court proceeding. The Judge Advocate General should address the issues of legality and acceptability of digitized images. The issues relating to image enhancement must still be

clarified in the future. Image enhancement will enable the Army to "improve" the quality of the image, even poor quality documents. This will be particularly appropriate when converting some poor quality images from the existing microfiche system.

The cost for developing a digital image system will be substantial. The existing microfiche images must be converted to digitized form, each image indexed and enhanced, and stored. Actual operations can begin during the conversion process. Whenever documents are received for updating, the original updatable microfiche will be converted to the digital image system; other microfiche records can be converted as time permits.

The cost for converting the system to digital image technology may be recovered for all installations within ten years. With the existing microfiche OMPF system, the RAM2 task force did not expect a payback after conversion during the lifetime of the system. The digital image system is cost justified due to the large reduction in operating costs for the system, improved services to users, and vastly expanded technical capabilities.

The Library of Congress is developing a pilot project to prove the feasibility of using digital image technology for the management and storage of library materials. Many more systems will be developed within the next two years. The Army should carefully monitor the activities of this technology, while developing its own system. It is expected that a pilot project costing approximately $1.9 million can be conducted in 1986, and conversion for all installations can begin by 1987.

In comparison to the existing microfiche OMPF system, the digital image technology will provide the Army with the following advantages:

- Higher system speed
- Improved image quality and error correction
- Ability to resequence or delete images
- No degradation in image quality
- Multiple access
- Rapid access to information
- Reduction in staff requirements and human intervention
- Potential for extraction of data from images through character recognition

CHAPTER 6. COMPARISON OF SYSTEM DEVELOPMENT ALTERNATIVES

Three alternatives for system development are available to the Army:

- Enhance and operate the existing updatable microfiche.

- Convert to a micrographics-based transition technology such as an automated document storage and retrieval system with digital image transmission.

- Convert to a digital image system, after a pilot test.

The system evaluation criteria were applied to these three alternatives. The digital image technology received the highest total score and was rated "best" in the following categories: image quality, security, image creation/management, systems development, dissemination/use, personnel, and environment. The existing system scored approximately 40% lower than the digital image technology. The systems were also reviewed in terms of operation and conversion costs, and the digital image system proved to be the least expensive.

The major factors which favor the development of a digital image system are as follows:

- The existing updatable microfiche system has severe weaknesses which cannot be resolved and adversely affect the operation and use of the system.

- Although some of the advanced micrographic-based transition technologies resolve many problems of the existing system, they have severe deficiencies, especially with the time required to assemble the complete OMPF record for an individual.

- The digital image technology responds to all problems with the existing system and offers several opportunities for improved operation. Some of the additional advantages offered by the digital image technology are image enhancement, multiple access of information, rapid access to information, reduction in human intervention, and potential for extraction of data from images. The major drawbacks relate to the newness of the technology and some concerns regarding image quality.

CHAPTER 7. SPECIAL APPLICATIONS OF MICROFILM

Potential microfilm applications were also reviewed in the Awards Branch, the Promotions Branch, and the Central Clearance Facility (Ft. Meade).

The Awards Branch is responsible for the administration and research of records of awards presented by the Army. Approximately 500,000 General Orders were produced during the Vietnam era. These records are actively used, are deteriorating through age and use, are subject to loss or destruction, and cannot be replaced. These records should be microfilmed on roll film, placed in cartridges for protection and retrieval, and used in place of the paper records.

The Promotions Branch maintains the records of non-selected officers. These records must be retained in the exact sequence and format as presented to the Boards. Since no statute of limitations exists on appeals, these records are frequently accessed to answer inquiries and to respond to litigation. These records should also be microfilmed on roll film and maintained in cartridges. The Army should also support the proposed five-year statute of limitations for appeals of Board decisions.

The Central Clearance Facility (Ft. Meade) is responsible for processing security clearances. No applications for microfilm existed under that command.

The Career Management Branches maintain separate filing systems consisting of copies of the most recent microfiche, the evaluation reports in paper form, and other documentation required to perform the career management function. It would be desirable in the future to eliminate paper evaluation reports and require the management staffs to rely on the microfiche or digitized record.

RCPAC has responsibility for maintaining the Military Personnel Records Jacket (MPRJ or 201 file) for separated individuals with a remaining service obligation and retirees. These files include medical records, 201 documents and a copy of the OMPF microfiche. The documents maintained in the MPRJ should be microfilmed and the paper destroyed.

CHAPTER 8. RECOMMENDATIONS

The following summarizes the major recommendations resulting from this project:

- The existing OMPF updatable microfiche system should be enhanced and maintained until a digital image system is developed.
- An alternative microfilm-based system should not be developed for the maintenance of the OMPF.
- A digital image system should be developed for maintenance of the OMPF.
- A pilot project using digital image technology should be implemented prior to full-scale conversion to a digital image system.
- The development of a digital image system should represent a consolidated project which includes all four facilities.
- Planning and budgeting for the digital image pilot project and system development should begin immediately.
- A digital image technology committee should be organized.
- The digital image system should be developed under the auspices of the Office of the Deputy Chief of Staff for Personnel (ODCSPER).
- The digital image system should be developed by Army personnel with records management and micrographics experience, with support services provided by data processing personnel.
- The detailed systems design should be developed in 1984.
- A systems integrator should be selected to develop the digital image system for the pilot project and total system.
- The Army should develop staff expertise in digital image technology or a liaison should be obtained by contract to represent the Army in dealing with the systems integrator.

- New developments in the field of digital image technology should be monitored on a regular basis.

- High speed image transmission capabilities (exceeding 5 million bits/sec.) should be provided within local area networks and the Defense Data Network for digital image transmission.

- Care should be taken to ensure that personnel requirements specify only highly qualified personnel to operate and manage the digital image system.

CHAPTER 1. OVERVIEW OF EXISTING OMPF MICROGRAPHICS SYSTEM

The Army Official Military Personnel File (OMPF) micrographics system can be viewed in terms of the basic system or concept, the implementation of the system at each facility, and the impact of the system on users. This chapter provides an overview of the existing system from these three perspectives.

1.1 MICROGRAPHICS SYSTEM OVERVIEW

1.1.1 Background

The OMPF is the official Army record of service, performance, commendations, decorations, and disciplinary action. Army regulation AR640-10 specifies the documents to be included in the OMPF.

During the early 1970s, the Army OMPF were maintained in paper format. Several problems with these paper records were encountered:

- A large amount of space was required for storage.
- There was difficulty in maintaining the file integrity since documents could easily be removed, inserted, or resequenced.
- There was no provision for system backup.
- A large staff was required to operate the system.
- The system was incapable of permitting two people to access the same record at the same time.
- Substantial time and effort was required to assemble records for Boards.

In July 1973, a major fire at the National Personnel Records Center (NPRC) destroyed or damaged approximately 17.5 million records. The consequences of the fire and the problems with the existing paper system served as motivating forces for change.

After several evaluations of the OMPF system, the review process culminated in April 1975 with the Records Administration in Microform Mode (RAM2) final report and recommendations. The task force evaluated problems with the paper filing system, alternative micrographic technologies, and systems developed by the Navy and Air Force. The system selected consisted of the A.B. Dick System 200 updatable microfiche system with Access-M retrieval equipment. Conversion of the paper OMPF files to microfiche began in 1976 at MILPERCEN, followed by conversion at EREC. (RCPAC and the National Guard were not included in the original RAM2 study for conversion). The conversion to the microfiche system is now complete and operational for officers and enlisted personnel at MILPERCEN and EREC; conversion is still proceeding at RCPAC and the National Guard.

1.1.2 System Description

Although there are minor operational variations at the four sites utilizing the OMPF micrographics system, procedures are remarkably uniform. The basic policies and procedures used are included in AR640-10.

Each individual may have separate microfiche included as part of the OMPF file:

- P-fiche: Includes performance data, evaluation reports (OERs or EERs) and commendatory and disciplinary (C&D) information.

- S-fiche: Includes service history, orders, and duty assignments.

- R-fiche: Includes disciplinary information not included on the P-fiche, adjudication proceedings, and other restricted (R) information.

These microfiche are maintained together as a unit record in a plastic carrier.

In essence, each installation handles four major tasks related to the OMPF file:

- Accessions: The term "accessions" is used in the OMPF system to indicate receipt of new records for an individual not yet having a record at the installation. Two types of accessions take place in the system. The first, and most common, is the processing of the accessions packet received when an individual is commissioned or enlists. The documents are processed, index entries made, a new original microfiche created, the accession documents filmed, and the original stored in the M-units.

  The second type of accession takes place whenever the status of an individual changes (e.g., an individual separates from the Army) and the records are transferred to RCPAC. The records, including the original microfiche created at the previous installation and the paper 201 file (MPRJ), are then accessioned into the RCPAC system for future processing. The records are then reviewed, indexed, and filed (or transferred to NPRC, if appropriate).

- Updates: Periodically, additional documents must be filmed and added to the OMPF. These procedures are described in Section 1.1.3.

- Separations: Whenever an individual changes status (e.g., separates from the active Army), the OMPF microfiche must be updated to indicate separation and the complete separation package (including the OMPF microfiche and the paper 201 field file) are transferred to RCPAC.

- Requests for Information: A large number of requests are received for OMPF information for use by Selection Boards, obtaining security clearances, planning careers, and insuring the completeness of the file. Generally duplicate copies of the microfiche are prepared for this purpose. An individual may also request a copy of his microfiche at any time.

In general, the microfiche system has resulted in substantial improvement of the management of the Army's OMPF. A detailed evaluation of the existing system is provided in Chapter 2 of this report.

1.1.3 System Procedures

All four facilities follow essentially the same procedures for operating the OMPF microfiche system. Some special procedures are sometimes followed due to particular problems related to the type of records managed or a difference in philosophy of the management staff at a facility. The basic procedures are as follows:

(a) Update Procedures. (See Figure 1.1)

(1) Document Preparation Screening. Documents are screened to determine if they qualify for inclusion in the OMPF. Staples and other fasteners for OMPF documents are removed.

(2) Computer Data Entry. The Social Security Number (SSN) is entered into the computer system to retrieve name (for verification purposes), Access-M unit address, and other related data.

(3) Sorting/Filing of Documents. Documents are sorted, when appropriate, and filed to await updating.

(4) Retrieval of Documents for Filming. When an evaluation report is received, the evaluation report and all other documents awaiting filming are generally removed from the paper filing system and begin the updating process. At EREC, all documents received for E6 and above are added to the microfiche within one week of receipt, while documents for E5 and below are added to the microfiche in a first-in, first-out order, after a substantial delay.

(5) Microfiche Retrieval. The updatable microfiche is retrieved from the Access-M unit based upon the M-unit address on the paper documents.

(6) Merging Microfiche and Documents. The microfiche and documents are brought together for filming.

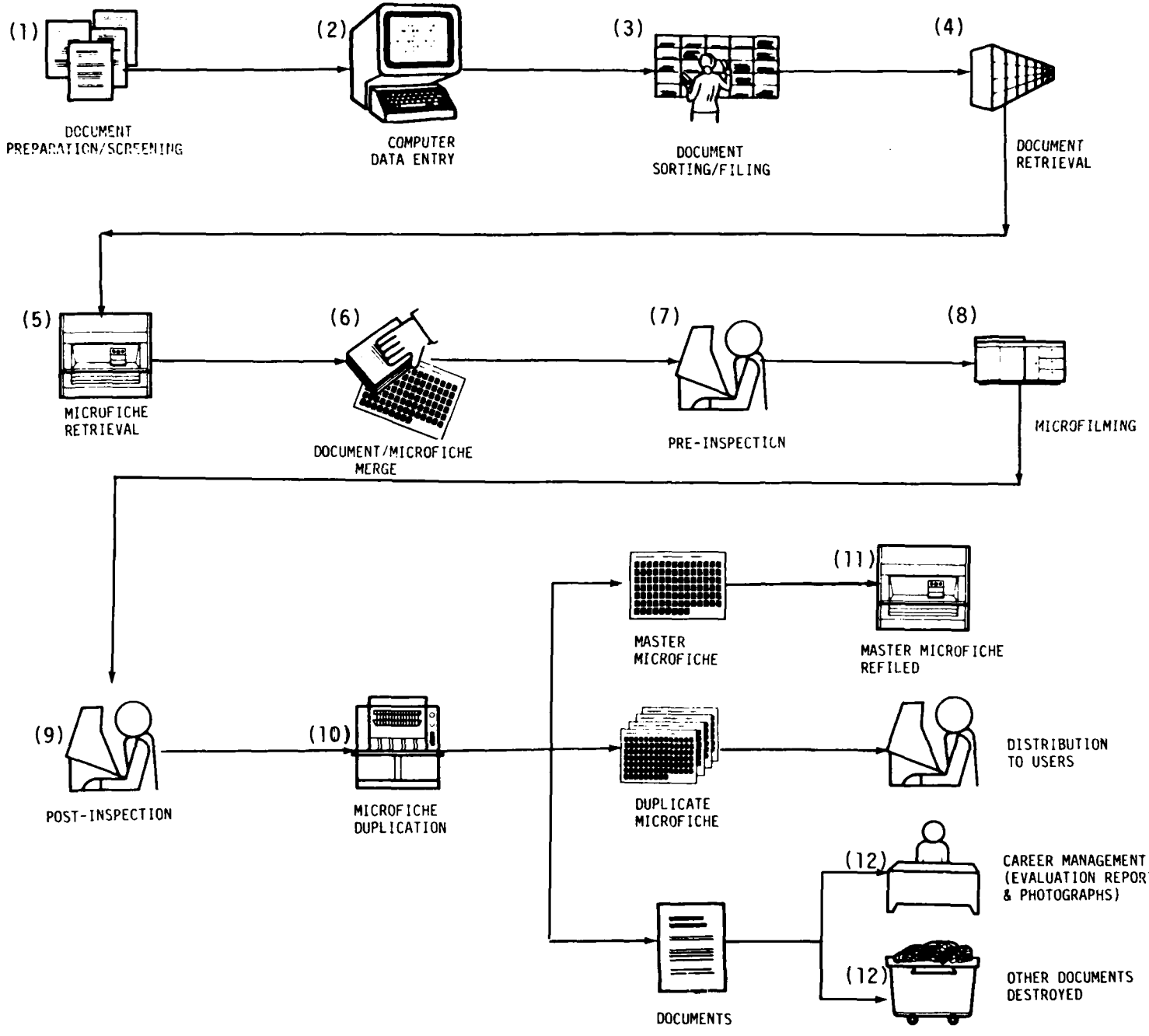
(7) Pre-inspection. The microfiche and the documents are inspected for duplication and other problems related to the new documents. The appropriate microfiche grid number for the next images is written on the documents at all sites except EREC. At EREC, the camera operator assigns the grid number.

(8) Filming. The camera operator inserts the original updatable microfiche into the camera, selects the appropriate grid number, and films each document. At the conclusion of filming, the operator visually determines that images were in fact placed on the film.

(9) Post-inspection. The original updatable microfiche is placed in a reader and inspected for basic image quality, image registration, and placement.

EXISTING WORKFLOW

Figure 1.1



(10) Duplication. MILPERCEN is the only installation providing a duplicate to the Career Management Branches each time the file is updated. After filming, the original microfiche is manually inserted into the duplicator, and a diazo duplicate is produced. The duplicate is then stapled to the evaluation report and transferred to the Career Management Branches.

(11) Refiling the Original Microfiche. The original microfiche are maintained centrally at each site. For refiling, the original microfiche are placed in the storage buffer of the Access-M unit in random order. At regular intervals, the original microfiche carriers in the buffer are returned to the appropriate cartridge. As each M-unit cartridge is retrieved, the microfiche in the buffer are "pushed out," removed from the buffer by the operator, and manually inserted randomly in the cartridge. For E5 and below at RCPAC, the microfiche carriers are refiled manually in Lektriever units, in terminal digit order by Social Security Number.

(12) Document Destruction. At MILPERCEN, EREC, and NGB, after post-inspection, the paper documents are destroyed except for evaluation reports and photographs. RCPAC destroys all documents.

(b) Accession Procedures. Information from the accession records are entered into the computer for indexing purposes, a label for the updatable microfiche is prepared, and documents are filmed as stated above.

(c) Separation Procedures. For the active Army and National Guard, separation documents are filmed on the original microfiche. The original 201 files (MPRJ) are then transferred to RCPAC. Upon discharge, RCPAC duplicates the original microfiche and transfers duplicate 201 files to NPRC.

(d) Request Procedures. Requests are entered into the computer or hand-carried to the appropriate M-unit, the original fiche is retrieved from the M-unit, a duplicate is made, the original is refiled, and the duplicate transferred to the requestor.

1.2 PERSONNEL RECORDS FACILITIES

Figure 1.2 presents some basic information related to the four facilities participating in the OMPF micrographics system. Each facility, while using a similar system, has implemented the system in a slightly different manner in order to meet the unique characteristics of its operations. Differences also result since each facility developed the system independently (no centralized organization or control was provided), in cooperation with the other facilities. In addition, each facility is responsible for preparing and obtaining approval for its own budget. Finally, the initial RAM2 project did not include provisions for converting records at RCPAC or the National Guard. These facilities were converted separately. Considering the normal process of the development of independent systems, the personnel micrographics system is relatively uniform in the four components of the Army.

1.2.1. Military Personnel Center (MILPERCEN)

(a) Background. MILPERCEN is responsible for maintaining the OMPF records for officers in the active Army. Conversion of these records was started in 1976 and completed in 1979.

Figure 1.2 Comparison of Personnel Records Facilities

	MILPERCEN	EREC	RCPAC	National Guard
Location	Alexandria, Virginia	Indianapolis, Indiana	St. Louis, Missouri	Falls Church, Virginia
Responsibility	Officers	Enlisted	Officers/Enlisted	Officers Enlisted (planned)
Volume (annual)--Estimated				
Records in System	102,000	675,000	330,000 (microfiche) 870,000 (paper)	32,000 (microfiche) 15,000 (paper)
Accessions	10,000	145,000	35,500 (reserves only) 160,000 (other sources)	5,000
Separations/Discharge	10,000	152,000	100,000	3,000
Documents Received	480,000	3,300,000	754,000	96,000
Images Filmed	950,000	8,501,000	1,131,000	180,000
Duplicate Microfiche Produced	900,000	451,000	360,000	100,000
Backlog--Documents	20,000	500,000	100,000	100,000
Equipment				
A.B. Dick System 200 Camera-Processors	5	16	6 (update) 8 (conversion)	*2 (update)
Access-M Units	3	12	4	2
Photomatrix Duplicators	2	2	3	1
Computer	Inforex 5000	Inforex 5000	Access IDCS (Hewlett-Packard)	Wang OIS 140
Other			14 Lektrievers	6 Lektrievers

*Conversion in progress off-site under contract at time of study.

(b) Findings and Problems. During the review of the OMPF system at MILPERCEN, the following problems were observed:

(1) A large amount of personnel time is required for document screening to determine OMPF status.

(2) The Career Management Branches are provided with microfiche copies of the OMPF whenever the originals are updated. The Branches, however, generally do not use the microfiche, relying instead on the paper evaluation reports and other paper documents maintained to meet their own needs. The paper evaluation reports are also used to help reconstruct the original fiche when necessary.

(3) Microfiche records are maintained by M-unit address rather than Social Security Number, requiring additional processing time and increased potential for errors.

(4) The Convenience Unit (responsible for correcting or changing the microfiche) is provided only limited access to the M-units to retrieve records for special requests.

(5) Since the microfiche duplicates are prepared 30 days prior to the meeting of the Selection Board, any documents received after that time must be provided to the Board in paper form.

(6) There have been delays and other problems in transferring records from MILPERCEN to RCPAC. During the first 120 days after a record has been transferred to RCPAC, problems can occur if the individual re-enlists or returns to active duty, and the record is required at MILPERCEN.

(7) Oversized documents must first be reduced using photocopy equipment prior to microfilming. The reduction process degrades image quality, due to the poor quality photocopier.

(8) Some computer-generated labels on the original fiche do not reproduce well on duplicates, because they have smeared and dulled over time.

(9) Duplicate microfiche are often of very poor quality. No quality control procedures exist for duplicates.

(10) No operating or procedures manuals exist to ensure uniform procedures, ensure system continuity, and enhance training for new staff.

(11) The working environment is not conducive to good morale or productivity. Equipment is noisy, ammonia fumes from the duplicator were detected, floors reflect noise due to lack of carpeting, temperature and humidity control is not adequate, and the subdued blue lighting appeared to cause eye strain, and, therefore, reduce productivity.

(12) When original microfiche are out-of-file for updating or duplication or have been misfiled, they are extremely difficult to locate.

(13) The procedures followed during pre- and post-inspection require that the original microfiche be inserted into a reader. This inspec-

tion method is slow and subjects the original microfiche to intense light, even if filtered, for brief periods of time.

(14) The Inforex 5000 computer system does not control the M-units and is not fully integrated with other personnel data base systems. This problem results in delays in processing and transferring information, since magnetic tape must be used.

(15) Work is often routine and morale tends to be low. Staff often is not cross-trained nor provided a variety of work assignments.

(16) The office layout is not conducive to efficient workflow.

(17) Problems of poor image quality are magnified whenever an entire microfiche must be reconstructed, especially when selected documents must be printed on a reader-printer and refilmed (since the original documents have been destroyed).

(18) Some older microfiche have lost their updating capabilities, generally due to repeated exposure to light, and must be reconstructed.

(19) Fingerprints are sometimes found on the original microfiche since no gloves are used by staff and the original is handled frequently. Fingerprints on the original could affect the quality of updates filmed at the location of the fingerprints. In most cases, the staff handles the microfiche carefully. Gloves were previously used for a six-month period but were abandoned due to a variety of problems.

1.2.2 Enlisted Records and Evaluation Center (EREC)

(a) Background. EREC is responsible for the maintenance of records for approximately 675,000 enlisted individuals in the active Army; as such, this is the largest of the four installations using the OMPF microfiche system. Conversion of these records began in 1976 and continued until conversion funding under RAM2 was depleted, leaving approximately 160,000 records still not converted. These records were subsequently converted as part of EREC's operating budget, as time permitted.

(b) Findings and Problems.

(1) Accession records are generally held for seven months (now thirteen months due to backlog) prior to filming to allow for attrition which occurs during this first six-month period; records for individuals discharged before completing six months service are not filmed. In some cases, update documents reach the filming stage prior to creation of the original microfiche.

(2) Due to the high volume of documents and existing staff size, only update documents for E6 and above are filmed upon receipt. Update documents for E5 and below are filmed on a first-in, first-out basis, up to seven months after receipt. E6 or above are given higher priority because they are evaluated centrally at EREC for promotion while E5 or below are promoted in the field.

(3) Approximately 30% of the original microfiche for E6 and above are inspected (since May 1983) and only selected microfiche for E5 and below are inspected.

(4) Staff size is not large enough to effectively operate the microfiche system at current volumes.

(5) There is an inadequate number of M-units, some cartridges are overloaded, resulting in some carriers getting stuck and requiring hand searches. While the units were designed to store approximately 35,000 - 40,000 microfiche carriers each, all of the units at EREC contain 50,000 or more carriers. When a carrier gets stuck in the M-unit, a response of "not in file" is received from the search. Improvements in processing time, especially for accessions, cannot be achieved because there is inadequate space available to store new original microfiche.

(6) Once an E5 and below document has been stored on the shelves (or on "the wall") in chronological order by date of receipt, there is no way to locate the document until it has been retrieved for filming.

(7) Documents for individuals E6 and above are sometimes mistakenly placed on "the wall" and processed like records for E5 and below. This occurs frequently after an individual has been promoted to E6 and receives a complimentary copy of the OMPF microfiche. The individual then submits documents for filming which were initially not included on the microfiche. The screening clerk examines the documents, notes the stated rank of E5 or below, and mistakenly processes the records accordingly.

(8) Since there is no document to trigger updates for E5 and below, the original microfiche must be retrieved and updated once for every document required for the OMPF file. Other installations film batches of documents at a single pass when the evaluation report is received.

(9) Special computer searches slow the computer response time for data entry and information retrieval, wasting staff time.

(10) The existing air conditioning and humidity control systems are inadequate to handle the heat generated by equipment, lighting, and personnel. As the temperature rises and humidity falls, the incidences of computer and camera failure increase.

(11) When an individual separates and then re-enlists, there is a delay in getting records returned from RCPAC which were shipped during the previous 90-120 days.

(12) Staff positions have been graded low (low salary levels) which contributes to low productivity, increased turnover, and higher than acceptable error rates. (Applicable to all sites.)

(13) Considering the volume of records, staff levels provided, and functions performed, the OMPF microfiche system at EREC functions well. The procedures are orderly and the facility is extremely neat.

1.2.3 National Guard Bureau (NGB)

(a) Background. The National Guard currently maintains OMPF records on microfiche for officers. Approximately 32,000 records have already been converted; the remaining 15,000 records will be converted within the next two months. The National Guard installation was not included in the original RAM2 study nor in RAM2 funding for conversion.

The National Guard is converting its systems and procedures to correspond identically to those followed by MILPERCEN. A new Wang OIS computer system is being used to control the M-units using Wang's list processing capabilities.

(b) Findings and Problems.

(1) The National Guard requires some additional documents on the OMPF (not provided for in AR640-10), primarily due to its retirement system. Although the same organization of the microfiche is used, the information maintained may not be completely compatible with the other sites.

(2) The volume of records is growing (accessions over separations) at a rate of approximately 2,000 per year. The National Guard believes this has occurred primarily from additional enlistments as a result of the poor economy; this growth is expected to change as the economy improves.

(3) A number of environmental problems affect image quality and operations. Office temperatures have reached over 90° in the summer; however, addition of a new air conditioner is planned. Humidifiers are also utilized in the winter to prevent humidity from going below 20%. In addition, it was observed that the room is extremely noisy, no carpeting was in place and the layout is not optimal for efficient workflow.

(4) The microfiche operation has a backlog of approximately 100,000 documents; much of the backlog resulted from conversion to new system procedures.

(5) Computer accession rosters are provided to the National Guard in alphabetical order, requiring that accession records be first sorted in alphabetical order for comparison with the roster. The records must then be sorted in M-address order for filing after filming.

(6) Records filmed on the microfiche may not always be complete. For instance, the states still have in their possession some OMPF records. When the individual was in the active Army, RCPAC and MILPERCEN should have already created a microfiche containing documents appropriate for the National Guard's OMPF file.

(7) Information related to inter-service transfers must be handled manually since the function is not currently performed by a computer.

(8) The National Guard purchased carriers for the microfiche without encoding. Substantial staff time is required to encode these carriers by hand.

(9) The M-address has been typed on the microfiche label along with the name and Social Security Number. This may create problems if the original fiche is sent to another installation, utilizing a different M-address.

(10) The National Guard has maintained a manual card file including the date of separation, date of separation order, and other related information. New separation records will be maintained on the computer system; the staff has expressed an interest in converting these several hundred thousand cards into a computer-readable format.

(11) When a request is received, it is difficult to determine whether the record is on microfiche, still in paper form, or has been sent to an outside contractor for conversion.

(12) A serious question exists regarding the creation of a centralized OMPF file for the enlisted records maintained by the states. The Army considers the state 201 file to be a federal record, subject to the Federal Privacy Act, while the states wish to retain control over this information. Pilot projects are now being developed to convert the over 300,000 enlisted records maintained by the states.

(13) Some of the updatable microfiche have lost their updating capabilities. When this problem occurs, paper prints are made of each image and the record refilmed with an associated reduction in image quality. (Applicable to all sites.)

(14) The National Guard continues to receive many documents which are not appropriate for inclusion in the OMPF file under AR640-10.

1.2.4 Reserve Component Personnel Administration Center (RCPAC)

(a) Background. RCPAC is unique among the personnel records facilities in that they have responsibility for managing reserve records as well as inactive records generated by the other components of the Army. Some records maintained or processed by RCPAC include the following:

- Records of the Troop Program Unit Personnel (TPU)
- Records of individuals separated from the Army with Reserve obligation
- Records of individuals discharged from the Army with no Reserve obligation (original microfiche only)
- Records of individuals transferred from the National Guard to the Reserves
- Records of retirees from the Army

All records related to any of these responsibilities are handled and processed by RCPAC. Records for individuals completely discharged from the Army or deceased veterans are subsequently transferred to the National Personnel Records Center (NPRC).

When an individual is separated, discharged, or retires from the Army, the MPRJ (Military Personnel Records Jacket or 201 file containing medical records

and other non-OMPF documents) is sent to RCPAC for processing along with the OMPF microfiche original. Since RCPAC is required to maintain the records of individuals in the Reserves, with Reserve obligation, or retired from the Army, RCPAC maintains a dual paper and microfiche system to meet its responsibility (paper MPRJ/microfiche OMPF).

RCPAC has not yet converted all of its Reserve records to the OMPF microfiche system. Since RCPAC did not participate in the original RAM2 project, conversion funding has been difficult to obtain. Conversion has diverted staff from daily operations. An outside contractor has assisted in the conversion process.

(b) Findings and Problems. The following problems were identified during the review of operations at RCPAC:

(1) RCPAC receives the separation packet (MPRJ plus original microfiche) sent from EREC or MILPERCEN shortly after the DD214, separation form, has been processed by those installations. After receipt of the packet, however, additional documents may be sent to RCPAC which must be added by RCPAC to the updatable microfiche original. The management of these documents interferes with the orderly processing of records at RCPAC.

(2) RCPAC must maintain a dual filing system--a paper filing system for the MPRJ and a microfiche file for the OMPF.

(3) RCPAC must maintain records of retired individuals with other active (not discharged) MPRJ's. These retiree records occupy a great deal of space and interfere with the orderly processing of the active records. The majority of activity affecting these files occurs within the initial two years after retirement. The Navy, Marines, and Air Force have transferred retired records to NPRC for maintenance; the Army has required RCPAC to maintain retiree records under the philosophy that the Army "takes care of its own retirees." NPRC could maintain these records if the philosophy changed, but would require additional space, staff, and an adequate budget.

(4) RCPAC must manage the micrographics system with an extremely small staff, considering the volume of records. Additional staff positions have not been approved.

(5) TAG unsuccessfully experimented at RCPAC with the concept of a microfilm data base with digitized image transmission during the Advanced Micrographic Access and Retrieval System (AMARS) project. This project failed primarily due to mechanical problems, poor image quality, and the requirement that duplicate microfiche be made for the system each time the original was updated. These problems must be overcome in any future digital image technology system developed. (Note: The AMARS project represents an early attempt at microfilm-based transition technologies discussed in Chapter 4 and bears little resemblance to the digital image technology discussed in Chapter 5.)

(6) Although the Access-M units can be controlled by the IDCS computer, changes in the software program are required to fully benefit from this capability. Currently, the computer program sorts M-numbers by units, but does not sort to an individual cartridge. The computer system also does not control batch management or retrieval for enlisted records.

(7) The adhesive from some of the microfiche labels sometimes get on the reader's glass platen during inspection, are transferred to the microfiche, and must be manually cleaned. (Applicable to all sites.)

(8) A substantial number of microfiche being requested (up to 40%) could be out-of-file for updating or duplication. This lag in turnaround time creates severe problems when new requests are received. No adequate method has been developed to re-process these requests when the microfiche is refiled.

(9) While M-units are used for officer records, Lektrievers are used for enlisted records. Records must be retrieved by hand within the power files' trays, and misfiles occur fairly frequently.

(10) White light exists in the areas where the power files are maintained; the white light has turned the top of several microfiche to a gray tone, and may be affecting the updatability of the microfiche.

(11) No quality control has been provided for the microfiche duplicates. The D-min for one duplicate examined was .48 and the D-max 1.58. Poor duplicates results in poor paper prints and makes reading the information difficult.

(12) The activity of the original microfiche records appears to be substantially higher than the estimates made during the RAM2 project for MILPERCEN and EREC. As such, the original film is subjected to much more harmful light than was anticipated and may lose its updating capabilities while the record is still active.

(13) Some delays in operations have resulted from delays in servicing equipment by company representatives. Due to the volume of equipment on site and the cost of maintenance contracts, on-site maintenance may be justified.

1.2.5 National Personnel Records Center (NPRC)

(a) Background. The NPRC is responsible for the maintenance of records for all individuals discharged from the Army and for all deceased Army veterans. The original updatable microfiche for discharged officers and enlisted men are also maintained by NPRC at their Winnebago site. RCPAC transfers microfiche to NPRC once per year. NPRC responds to questions related to all records within its custody. In 1973, approximately 17.5 million military records for veterans discharged between 1912 and 1959 were destroyed by fire at NPRC.

(b) Findings and Problems.

(1) Although NPRC responds to all requests for information from records in its custody, requests for changes to the microfiche are transferred to RCPAC for response. This places an additional burden on RCPAC personnel and adds an additional level of records handling.

(2) The duplicate microfiche copies maintained in NPRC's paper files (for cases where microfiche was created) often are poor quality. These duplicate copies are difficult to read and make poor quality prints on the reader-printer.

(3) The reader-printer at NPRC produces negative prints from a positive image. Users prefer positive prints.

(4) NPRC maintains a large storage area for records of discharged personnel. Although a water sprinkler system and other improvements have been added since the fire, these records are still susceptible to damage because these records may be the only copies in existence (except for the OMPF microfiche where it exists). Substantial hardship to both individuals and the Army could result if these records were destroyed.

1.3 SYSTEM USERS REQUIRING OMPF INFORMATION

1.3.1 Selection Boards/Secretariat

Selection Boards (referred to as "Boards" in this report) are responsible for reviewing military records and making decisions related to promotion, special training, and education. Prior to the meeting of the Board, a list of candidates is prepared and presented to the appropriate personnel records facility. The list or roster is then used to retrieve and duplicate the P-fiche component of the OMPF. Some installations, such as RCPAC, provide copies of the microfiche to Career Management personnel prior to the meeting of the selection Board in order to ensure that the OMPF record is complete; updates to the P-fiche are then made prior to the Board review. Documents received after microfiche duplication are provided to the Board in paper format.

The Boards consist of a group of high-ranking Army personnel; the makeup of each Board is dependent upon the nature of the activity involved and the number of candidates to be considered. The Board members generally convene at a central site for several weeks' duration to review the candidates' microfiche and render their decisions. Boards are generally divided into smaller panels consisting of at least three individuals who generally review all records for a particular military occupational specialty (MOS). Board members have indicated the importance of meeting together in order to exchange information in areas of expertise and to isolate themselves from the interruptions and potential influences at their home bases. (Note: At the beginning of this project, the Army expressed an interest in developing a system for the OMPF which would enable individuals on Boards to remain at their home bases. The overwhelming opinion of the Boards clearly indicate the necessity to meet together.)

Each facility provides special rooms for the Boards to meet. Microfiche readers are provided to each individual on the Board. (See Section 3.3 for further analysis on readers and related equipment.) Secretariat personnel provide administrative support to the Boards and ensure that each Board member has a sufficient number of records to review each day.

Chapter 2 summarizes the results of a questionnaire administered to Boards at the four installations. The questionnaire was prepared to provide quantitative information regarding the scope of problems experienced by the Board as related by Board members, Secretariat staff, and other military personnel. The responses to the questionnaire and the ultimate conclusions are critical in determining new directions for the OMPF system since Board decisions related to promotion and advancement of individuals have a major influence on the quality and the readiness of the Army. The existing microfiche system is only a tool to assist and facilitate the Board process, and should in no way influence or alter the ultimate decision.

1.3.2 Promotions Branch

After the Boards meet and render their decisions, the records reviewed by the Board for individuals not selected are maintained by the Promotions Branch. The Promotions Branch maintains computer records, paper records, and microfiche records representing the administrative processes followed and the exact records reviewed by the Board. This material must be kept for long periods of time in case the Board's decision is appealed. Currently, there is no statute of limitations on appeals, although a bill designating a five-year statute of limitations is now pending in Congress. As a result, appeals could be brought at almost any time. A successful appeal may impact the decisions of one or more Boards.

1.3.3 Career Management Branches

The Career Branches are responsible for assigning individuals to new duty, assisting individuals in improving and developing skills and experience and ensuring that the Army has the qualified individuals necessary to perform designated tasks. The Branches maintain files for each individual consisting of some administrative documents and some documents, such as evaluation reports, which are duplicates of documents filed in the OMPF system. In fact, a copy of the latest OMPF microfiche is also maintained in the paper file with the other documents.

The paper records system of the Career Branches serves a valuable function. Periodically, an original updatable microfiche must be reconstructed. When this occurs, the original evaluation reports are used to produce the new microfiche. This approach is far superior to making paper prints from microfiche and refilming on a new fiche. This also provides some degree of security backup to the original microfiche. On the other hand, it appears wasteful to have duplication in the filing systems.

1.3.4 Personnel Action Branch (EREC) or Reference Services (MILPERCEN)

These agencies are responsible for submitting changes and corrections to the OMPF. Some of the tasks performed include change of name (due to change in marital status), correction of images generally detected by the individual, removal of documents, and determination of length of service. These agencies complain of delays in obtaining copies of the OMPF to perform their function. This is particularly troublesome since many of the employees have production quotas which are compromised by these delays. In addition, some information required by the agencies does not exist on the OMPF and must be reconstructed from other sources.

1.3.5 Field Assistance Branch (EREC) or Reference Services (MILPERCEN)

These agencies are responsible for responding to written or telephone requests for information from the OMPF, or copies of documents or the entire OMPF microfiche.

1.3.6 Defense Investigative Service

Each facility has designated personnel responsible for handling inquiries and requests for information related to security clearance. Primarily due to restrictions of the privacy act, only designated individuals can access the OMPF to provide background information to an outside agency for making the necessary decision on security clearance. These personnel expressed concern that the delays in obtaining copies of the OMPF microfiche hamper their operations.

1.3.7 Military Personnel

Military personnel are encouraged to review their own records at least annually to ensure that the OMPF microfiche is complete. This review is particularly important for all officers and all enlisted personnel E6 and above. In fact, EREC provides a courtesy microfiche to each individual promoted from E5 to E6 so that the records can be reviewed by the individual and updated as appropriate (since promotion review for enlisted personnel E6 and above will now be handled centrally). All military personnel have a vested interest to ensure that their OMPF are complete and correct.

1.3.8 Other

A large number of other users also have an interest in the OMPF system. These include the Veterans Administration, employers, insurance companies, and pension managers. The OMPF is also used for special studies such as the current Agent Orange project where the OMPF is used to determine whether an individual was subjected to possible Agent Orange exposure in Vietnam.

CHAPTER 2. EVALUATION OF EXISTING OMPF MICROGRAPHICS SYSTEM

This chapter provides the overall assessment of the Army's OMPF microfiche system, including system evaluation criteria, Board questionnaire results, and an overall assessment of the system.

2.1 SYSTEM EVALUATION CRITERIA

Figure 2.1 indicates the System Evaluation Criteria developed as part of this project and the score attained by the existing system. The final criteria resulted from review of questionnaires completed by both the Project Committee and the Project Staff, interviews with Army personnel and vendors, and the assessment of the existing OMPF microfiche and potential alternative systems.

The components of the evaluation criteria are as follows:

- Weight: the importance of the criterion in evaluating the system. (Maximum weight is 5 indicating "very important;" minimum weight is 1 indicating "not important.")

- Score: rating value for each criterion in terms of how well the system meets the criterion. (Maximum score is 5 indicating "excellent;" minimum score is 1 indicating "poor.")

- Weighted Score: the result of multiplying the Weight by the Score.

- Adjusted Score: each criterion has been included into functional groups of related criteria. The 10 functional groups were developed to help compare broader topics (instead of 37 individual criteria) and to permit the use of an unlimited number of criteria in each group, without unfairly skewing the results.

  Each group score or "Adjusted Total" was developed by using the average Weighted Score and adjusting that score by the average Weight of the group. For example, the "Image Quality" and the "Security" groups had an average weight of 4.67. The average Weighted Scores of these groups were adjusted so that a maximum score of 100 was possible. The Adjusted Totals for these groups were less than 100, only because the average Score for each group was less than 5. The other group scores were similarly adjusted, so that the low rated group, "Environment," could have achieved a score of 48, at best.

  The ranking of the functional groups clearly indicates the significance of the group in future system selection.

The Weighted Scores (for individual criteria) and the Adjusted Scores (for functional groups of criteria) will be compared in Chapter 6 with the evaluation for both the micrographic-based transition technologies and the digital image technology.

Figure 2.1 Evaluation of Existiing OMPF Microfiche System Based on System Selection Questionnaire.

System Selection Criteria	Weight	Score	Weighted Score	Adjust. Total
Image Quality				
a. Readable image	4.67	3.00	14.01	
b. Ability to delete error/image	5.00	1.25	6.25	
c. Ability to resequence images	4.67	1.50	7.01	
d. Ability to enhance poor images	5.00	1.50	7.50	
e. Acceptable reproduction of photo	4.00	1.50	6.00	
ADJUSTED TOTAL				32.61
Security				
a. Backup for data and images	4.67	4.00	18.68	
b. Restricted access to information	4.67	2.25	10.51	
ADJUSTED TOTAL				58.40
Integrity				
a. Ability to retain image 75 years	4.00	1.67	6.68	
b. Safeguards to prevent lost info.	4.33	2.50	10.83	
ADJUSTED TOTAL				31.24
Reliability/Maintenance				
a. Reliability of system	4.60	3.33	15.32	
b. Responsive vendor support and maintenance	4.00	4.00	16.00	
ADJUSTED TOTAL				57.70
Image Creation/Management				
a. Rapid image capture	3.67	2.33	8.55	
b. Rapid information retrieval	4.30	2.00	8.60	
c. Ease of updating record	4.00	3.67	14.68	
d. Ease of retrieving information	4.67	2.33	10.88	
e. Ease of indexing	3.50	3.33	11.66	
f. Ease of making backup	4.00	1.33	5.32	
g. Minimal filing/handling of record	2.30	2.00	4.60	
h. Potential to reduce human errors	4.00	3.33	13.32	
i. Minimal human intervention	4.00	2.33	9.32	
ADJUSTED TOTAL				31.67

System Selection Criteria	Weight	Score	Weighted Score	Adjust. Total
System Development				
a. Use of proven technology	3.33	2.67	8.89	
b. Flexibility to develop new systems	4.00	2.33	9.32	
c. Minimal disruption of current system during conversion	3.67	2.50	9.18	
d. Potential for paperless office	3.67	4.33	15.89	
e. Potential for automatic extraction of data from images	4.00	2.50	10.00	
ADJUSTED TOTAL				34.09
Dissemination/Use				
a. Rapid transmission of images between sites	3.00	1.33	3.99	
b. Rapid access to images by users	3.67	2.33	8.55	
c. Ability to retrieve images while record is being updated	4.00	1.33	5.32	
ADJUSTED TOTAL				18.15
Personnel				
a. Minimal staff size	2.67	2.33	6.22	
b. Minimal staff training	3.33	3.33	11.09	
c. High job satisfaction	2.67	2.33	6.22	
ADJUSTED TOTAL				19.42
Cost				
a. Low system conversion cost	2.67	2.33	6.22	
b. Low system operating cost	2.60	2.33	6.06	
ADJUSTED TOTAL				13.86
Environment				
a. Minimal space requirements	2.33	2.67	6.22	
b. Minimal noise level	2.00	2.50	5.00	
c. Comfort of working environment	2.33	3.25	7.57	
ADJUSTED TOTAL				11.92
TOTAL				309.06

2.2 BOARD QUESTIONNAIRE

Figure 2.2 provides the results from a questionnaire completed by 116 Board members, some from each of the four sites. This questionnaire was developed in order to confirm selected comments received by the Project Staff during the course of this project. Some of the concerns raised in interviews and through second-hand comments raise sufficient concerns to warrant a more exhaustive examination.

The Secretariat staff who administered the questionnaire expressed concern regarding the phraseology of some questions. The phrases used in this questionnaire were deliberately selected in order to elicit responses of a specific rather than a general nature. Project staff also used two questions, in some cases, to either verify a response, isolate a specific problem, or separate responses representing personal opinions versus trends believed followed by Boards. Additional questionnaires are welcome to further explore the impact of the micrographic system on Boards.

Due to the importance of Boards and the significant responsibilities of the individuals involved, the conclusions from this questionnaire are particularly significant:

- Most Board members prefer the microfiche to the paper records.
- Blacked-out images on the microfiche may be considered by a significant number of Board members in evaluating a record.
- Filming errors on the microfiche slow down the review of most Board members.
- Most Board members believe some information included on the microfiche, especially letters of appreciation, are useless for the evaluation.
- Most Board members indicated that their eyes are tired after reviewing the microfiche records all day; the cause of this problem may be the bright background of the positive image or something else. A significant number of comments indicated that the microfiche readers and work stations may be responsible for fatigue.
- A significant number of Board members indicated that they would prefer a paper photograph rather than a microfiche image of the photograph.
- Many Board members, in the comments, expressed concern regarding the quality of images produced in the system.

2.3 OVERALL ASSESSMENT

While a number of significant problems exist in the system (see Section 2.4), the system must receive a good evaluation overall. Some positive conclusions related to the overall system are as follows:

Figure 2.2 Summary of Selection Board Questionnaires.

Key: 1 - Disagree 5 - Agree	EREC E7	RCPAC	MILPERCEN						TOTAL ALL SITES
			LTC CA CMD	LTC CSSCMD	CPTCH	CSC	Other	TOTAL	
1. My eyes are tired after reviewing microfiche records all day.	4.4	3.0	4.45	4.7	1.5	4.6	4.88	4.4	4.33
2. Blacked-out images on the microfiche may indicate problems with a candidate for promotion.	3.2	4.25	2.55	3.4	1.0	2.5	3.17	2.68	3.01*
3. The microfiche is missing information needed to evaluate an individual.	3.7	4.5	1.5	1.4	1.0	2.9	2.25	2.05	2.97
4. I could complete my evaluation without the photograph.	2.1	1.5	1.5	1.3	2.0	3.6	1.87	2.27	2.15
5. Filming errors on the microfiche slow down my review of the record.	4.3	4.75	3.8	3.6	3.0	4.8	4.28	4.13	4.24*
6. No Board members consider the presence of blacked-out images when evaluating the record	2.7	3.33	3.0	3.25	1.5	4.0	2.5	3.17	2.95*
(Responses indicating "Don't Know")	(10)	(1)	(8)	(3)	(0)	(2)	(3)	(16)	(27)
7. I prefer the microfiche to the paper records.	4.6	2.0	4.5	4.3	3.5	4.4	4.86	4.43	4.39*
8. Some required information on the microfiche is useless for my evaluation.	3.7	3.25	5.0	4.75	4.0	4.1	4.75	4.54	4.07*
9. The bright light from the background of the microfiche image is uncomfortable.	3.0	2.0	3.91	3.1	1.5	2.9	2.5	3.0	2.95
Average Number of Boards on Which Respondents Participated	1.48	2.5	2.0	1.33	1	1.6	2.5	1.8	1.68
Average Number of Years in Military Service	24	29	24	24	20	23	25	24	24
Number of Responses	56	6	13	9	4	18	10	54	116

*Includes significant results

- The decision of the RAM2 committee was correct to convert to an updatable microfiche system with automated retrieval equipment. In 1975, the RAM2 committee completed an exhaustive review of the existing OMPF system and alternative systems available at that time. Considering the alternatives that were available, the updatable microfiche approach using the A.B. Dick System 200 and Access-M retrieval equipment appears to have been a good decision considering the total system benefits.

- The existing microfiche system performs better than the previous paper system. Almost everyone interviewed during the course of the project firmly believes that the microfiche system is substantially better than the paper system. Minimally, the conversion to the microfiche system forced the Army to clean up the OMPF file, destroy valueless documents, and develop streamlined procedures. Due to the existence of the microfiche system, the conversion to any future system can be completed more quickly, more accurately, and at less cost. Only two or three individuals among those interviewed at all four sites would prefer to return to the old paper system.

- The microfiche system meets the Army's needs. The microfiche system has enabled the Army to provide better information in less time to a wide assortment of users. The integrity of the OMPF file is also preserved, since only authorized personnel get access to the original records and it is much more difficult to lose information in this system compared to the paper system.

- The microfiche system will enable the Army to function during the timeframe 1985-1990, but problems will continue to exist over that period. With the changes to the microfiche system recommended in Chapters 3 and 8, the Army can continue to effectively function with the existing system for several more years. The problems evident in the system, however, will continue to worsen, and become more acute and troublesome in the late 1980s. Some reasons for the system degradation are as follows.

    - Some problems evident in the existing microfiche system cannot be solved other than through a complete conversion to a new system. (See Section 2.4.1.)

    - Some Army needs are not being fully met by the microfiche system. (See Section 2.2 for Board concerns.)

    - Based on current technology, system services and capabilities can only be marginally improved at best. (See Chapter 3.)

- The original microfiche cannot be used in future system development; the original microfiche, however, can be converted into a new format for use with the new technologies. Although several vendors have touted the use of microfiche as a data base for the micrographics-based transition technologies, the original updatable microfiche probably cannot be used that way due to its delicate nature. As such, the original microfiche will have to be converted into some other form (probably digitized) for use in future systems.

2.4 PROBLEMS WITH THE EXISTING SYSTEM

This section is divided into two components. The first part indicates problems with the existing system which cannot be resolved. The second part indicates problems for which appropriate solutions are available.

2.4.1 Problems for Which No Solution is Available

The following problems represent the most serious ones related to the existing system. No solutions have been discovered to resolve these problems, other than total conversion of the microfiche system to another system, such as digital image technology. These problems cause severe difficulty with system operation and have an apparent negative impact on the use of OMPF information, especially by the Boards. As such, these problems represent the primary reason why the Army should convert to another image processing system by the late 1980s.

(a) Inability to Erase and Resequence Images. The A.B. Dick System 200 original film cannot be erased at all. In some instances, camera operators superimpose the word "void," "error," or other similar word to signify that an image should not be considered when reviewing the film. This approach is used for operator errors, camera problems, documents out of sequence, documents on the wrong microfiche, documents out of registration, and other problems related to the microfiche. An alternate method is to black out the image completely.

As a result of the inability to erase, the microfiche is difficult to review in some cases. The results of the Board questionnaire in Section 2.2 clearly indicate that the review of microfiche records by the Board is slowed down substantially by these problems. Considering the cost for constituting a Board and the additional strain placed on these individuals by errors on the microfiche, this problem results in economic loss to the Army as well as potential loss of efficiency in the decision making process.

(b) Degradation of Updating Capabilities of Updatable Microfiche. While there appears to be no evidence indicating that the updatable microfiche image will fade or deteriorate over time, there is now substantial concern regarding the loss of updating capabilities of the film over time. Each time the original microfiche is exposed to light, room lights, readers, or duplicators, the updating capability of the microfiche degrades to some degree. Even though blue lights are used to filter out damaging light waves below 4,000 angstroms, any exposure to light will have some degrading tendencies. A.B. Dick has indicated that the film is expected to retain its updating capabilities for 20 years under normal office environment. Since it is readily accepted that the Army environment is not normal and that the film is exposed to more light than is normally expected, the microfiche will lose its updating capabilities much sooner. Some incidents of loss of updating capabilities have been discovered for original film less than 8 years old; no information is available on the actual usage and handling of the original in those cases.

An unscientific artificial aging test was performed by the project staff which demonstrated that images can be placed on the microfiche at density levels much below standards, after the microfiche updating capability has degraded substantially. (See Section 3.1.1 and Figures 3.1 and 3.2.) No method exists

to test each individual microfiche prior to filming, to determine the degree of degradation of its updating capabilities that has already occurred. It can be expected, therefore, that in several years, images will be filmed on the microfiche in areas where the upgrading capabilities have degraded significantly; inspection operators will have no means to determine that the density of these images is in fact substandard, other than by visual means. It may be several years before it is finally determined that a particular original has lost its updating capabilities. By that time, several images will already be on the fiche which may duplicate poorly or not at all.

Besides concern for the quality of the image, this problem also creates serious operational problems. Whenever an original loses updating capabilities, paper prints must generally be made of the documents, or existing paper copies obtained (when they exist) from the Career Management Branch or the individual. The microfiche is then reconstructed on fresh film so updating can continue. The reconstruction process is expensive and time consuming, and results in poorer overall image quality, especially if reader-printer paper prints must be used.

(c) Slow System Speed. The speed of filming and retrieval is limited by the speeds of the A.B. Dick System 200 camera processors and the Access-M retrieval units. Since 1976, A.B. Dick has not made any significant improvements in the speed of their camera processor. The Access retrieval system speed may be improved through the use of computer control and the Automatic Delivery System (see Section 3.5); but the speed will still be at least 10 to 15 seconds per carrier because of the relatively slow rotational speed of the cartridge and electromechanical ejection system.

(d) Inability to Adequately Reproduce Photographs. Most installations have stopped microfilming the photographs because of poor reproductions on the updatable microfiche original and subsequent duplicates. The Boards are currently provided paper photographs instead. The updatable microfiche technology simply does not allow the contrast and gray scale required for photographs.

(e) Lack of Simultaneous Access to Original Microfiche During Update and Duplication. A number of requests for the original microfiche are received when the original is "out-of-file" for updating or duplications. Procedures have been developed, such as utilizing the evaluation report to drive the update, to reduce the out-of-file conditions. Whenever a request for information from the OMPF file is delayed because the original is out-of-file, there is an impact on the productivity and quota requirements of the requestor.

(f) Duplication Requirements for Distribution of Information. The original microfiche must be duplicated prior to distribution of information to users; this may require several days due to the backlog of work and result in an out-of-file condition for the original. In addition, the quality of duplicates does not appear to be adequate to convey the information provided in the original. (The problem of poor duplicates can be corrected, however, through the recommendations provided in Sections 3.2 and Chapter 8.)

(g) Requirement for Human Intervention at Each Stage of the Process. The nature of the updatable microfiche system requires that humans be involved

in handling the original fiche during pre-inspection, filming, post-inspection, duplication, etc. In most cases, while the task performed requires some judgment, the actual handling of the microfiche does not. Due to the delicate nature of the updatable microfiche, however, robotic devices cannot be used for handling the original fiche.

2.4.2 Other Problems and Concerns

The following problems represent only a few of those encountered during the course of the project. Several solutions are provided in Chapter 3 and Chapter 8 of this report.

- Readers and reader-printers are often dirty and some are poor quality.
- Positive duplicates produce poor prints in most reader-printers.
- The camera processors, retrieval units, and original film are only available on a sole-source basis. This could create a substantial problem if either A.B. Dick or Access should go out of business.
- Some labels smudge with handling and duplicate poorly.
- No standard procedures manuals exist to ensure uniformity, train staff, and insure continuity of the system.
- Many jobs are entry level or low-paying jobs. OMPF files, however, are extremely important records upon which the careers of individuals and the success of the military is dependent.
- Fingerprints are sometimes accidentally placed on the original microfiche, requiring cleaning.

CHAPTER 3. MICROGRAPHICS TECHNOLOGY ISSUES RELATED TO EXISTING SYSTEM

This chapter discusses the major micrographics issues related to the existing OMPF microfiche system. Each major component of this technology is reviewed below.

3.1 MICROGRAPHICS IMAGING SYSTEMS

3.1.1 Updatable Microfiche

The existing OMPF microfiche system utilizes A.B. Dick System 200 updatable microfiche and camera-processors to produce a unit record. Updatable microfiche was selected primarily because all images related to a personnel record could be maintained together, additional images could easily be added to the microfiche, and production is simplified compared to traditional microfilm. Many of the major problems with the existing system described in Chapter 2 are attributable to the updatable microfiche technology. Some of the technology's limitations are as follows:

- System Speed. Images can be added to the updatable microfiche in the Army's production mode at a maximum rate of approximately 22-27 seconds per image (including paper handling, microfiche handling, exposure time, and system operation).

- Delicate Nature of Original Film. Original microfiche is easily scratched or damaged with improper handling. A scratch can interfere with the electrical conductivity of the film and prevent the addition of new images. As such, the original must be protected in the plastic carrier, precluding the use of a more automated retrieval device.

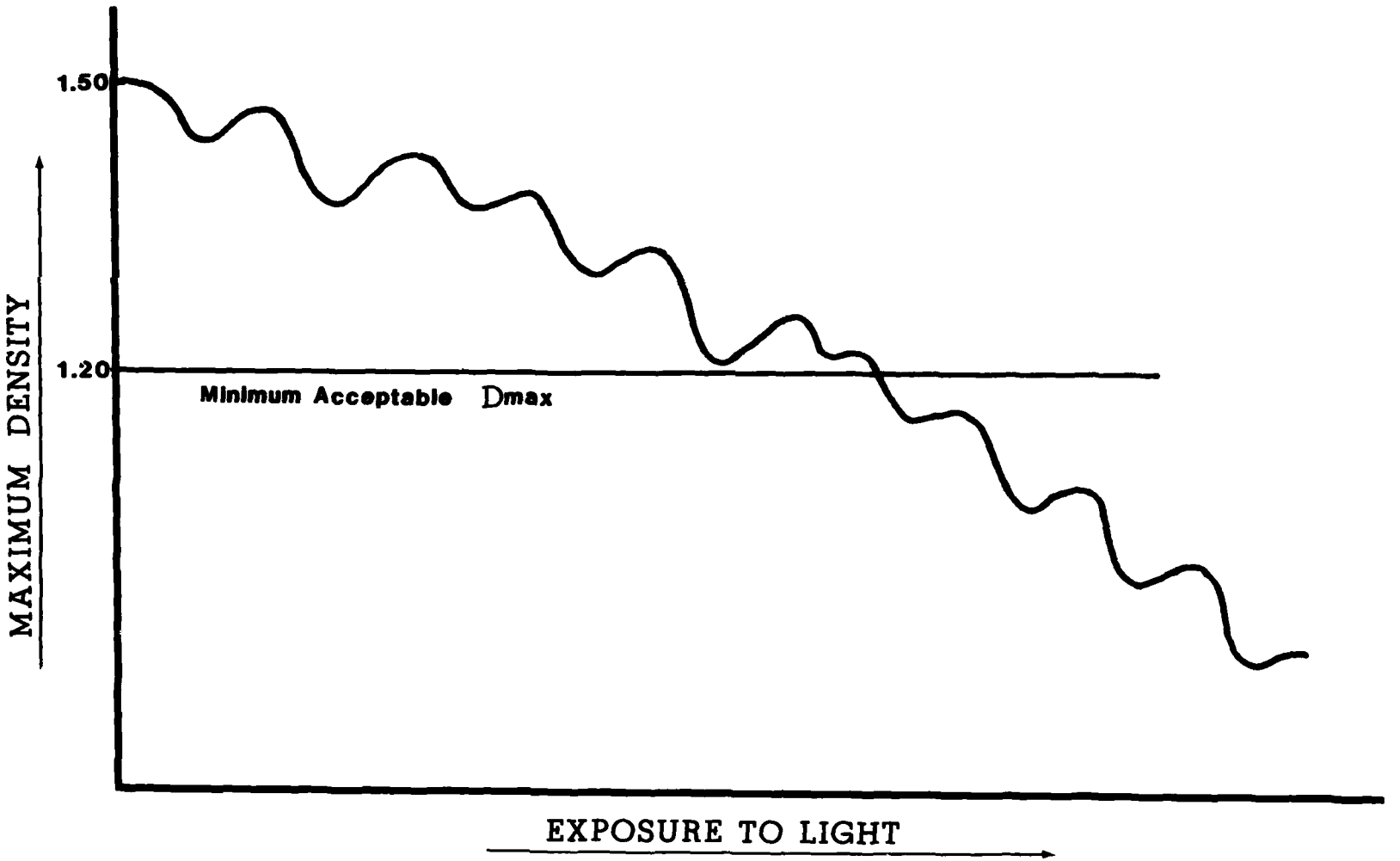
- Lack of Erasing Capability. The microfiche image cannot be removed or exposed in case of expungement or error, nor resequenced in case of errors or receipt of subsequent out-of-sequence documents.

- Loss of Updating Capabilities. Although there is no present concern regarding the loss of actual images, the film is sensitive to light and its updating capability degrades with each subsequent exposure to light. Figure 3.1 shows the expected degradation curve for updating. The figure indicates that at some future activity level, the film will degrade to a point where an acceptable image cannot be obtained. Images produced just prior to the loss of updating capabilities may also be inadequate. No known method exists to properly test the film for the status of its updating capabilities, prior to filming.

  An unscientific test was conducted to determine the effect on image quality when the updatable microfiche began losing its updating capabilities. Figure 3.2.a and 3.2.b are pictures made by an electron microscope showing the changes taking place in the A. B. Dick updatable microfiche as a result of exposure to light. Figure 3.2.a contains pictures no. 1, 2, and 3 (taken at magnifications of 54X, 200X and 1000X, respectively) taken of a resolution

Figure 3.1

IMPACT ON NEW IMAGE DENSITY OF CUMULATIVE EXPOSURE TO LIGHT OF A B DICK FILE FILM



Update (Maximum density) degradation is a function of:

1. Light Intensity
2. Light Wavelength
3. Exposure Duration
4. Number of Previous Exposure Cycles
5. Time

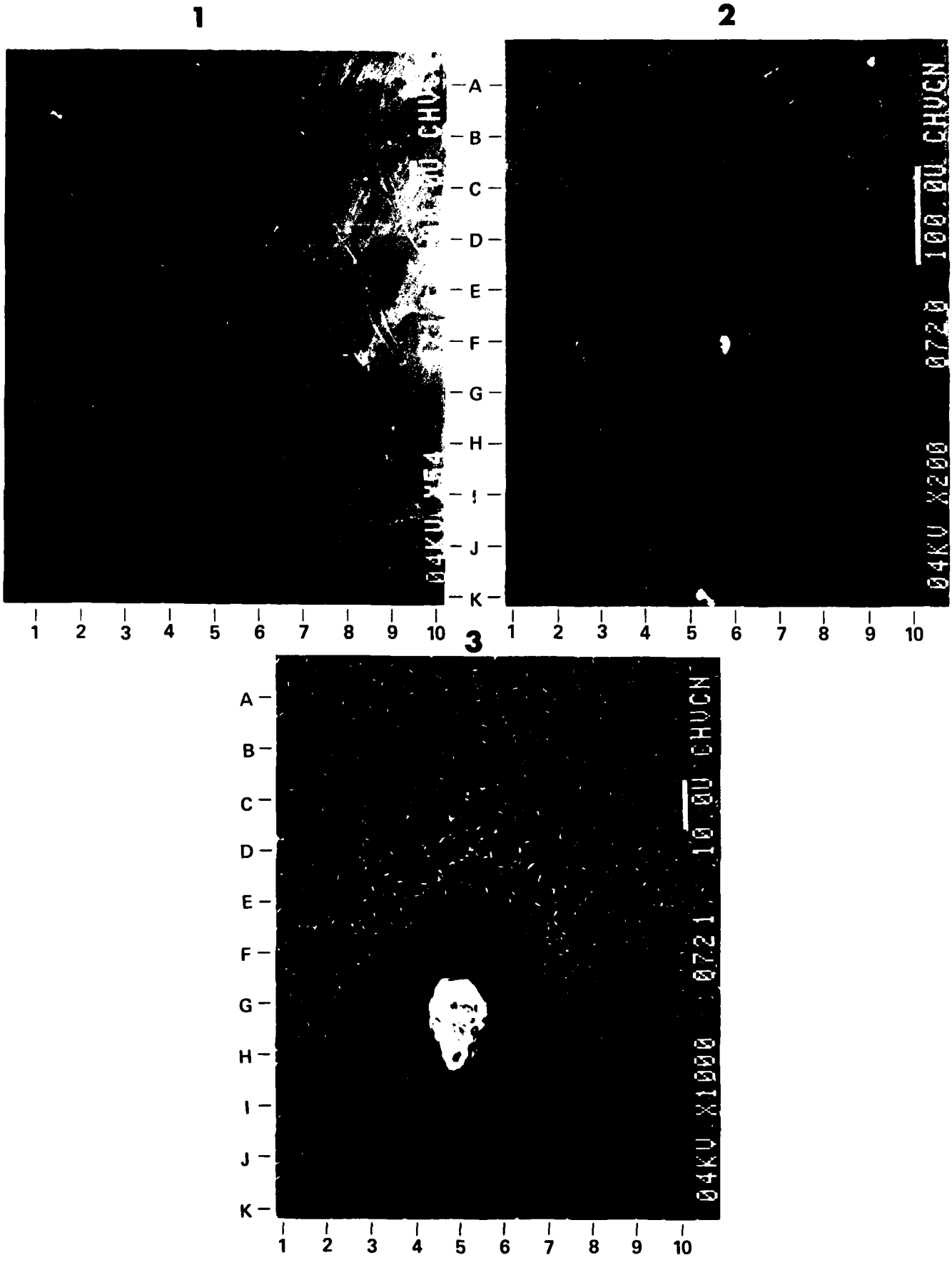


Figure 3.2a. Pictures of A. B. Dick System 200 Master Updatable Microfiche Exposed to Normal Light.

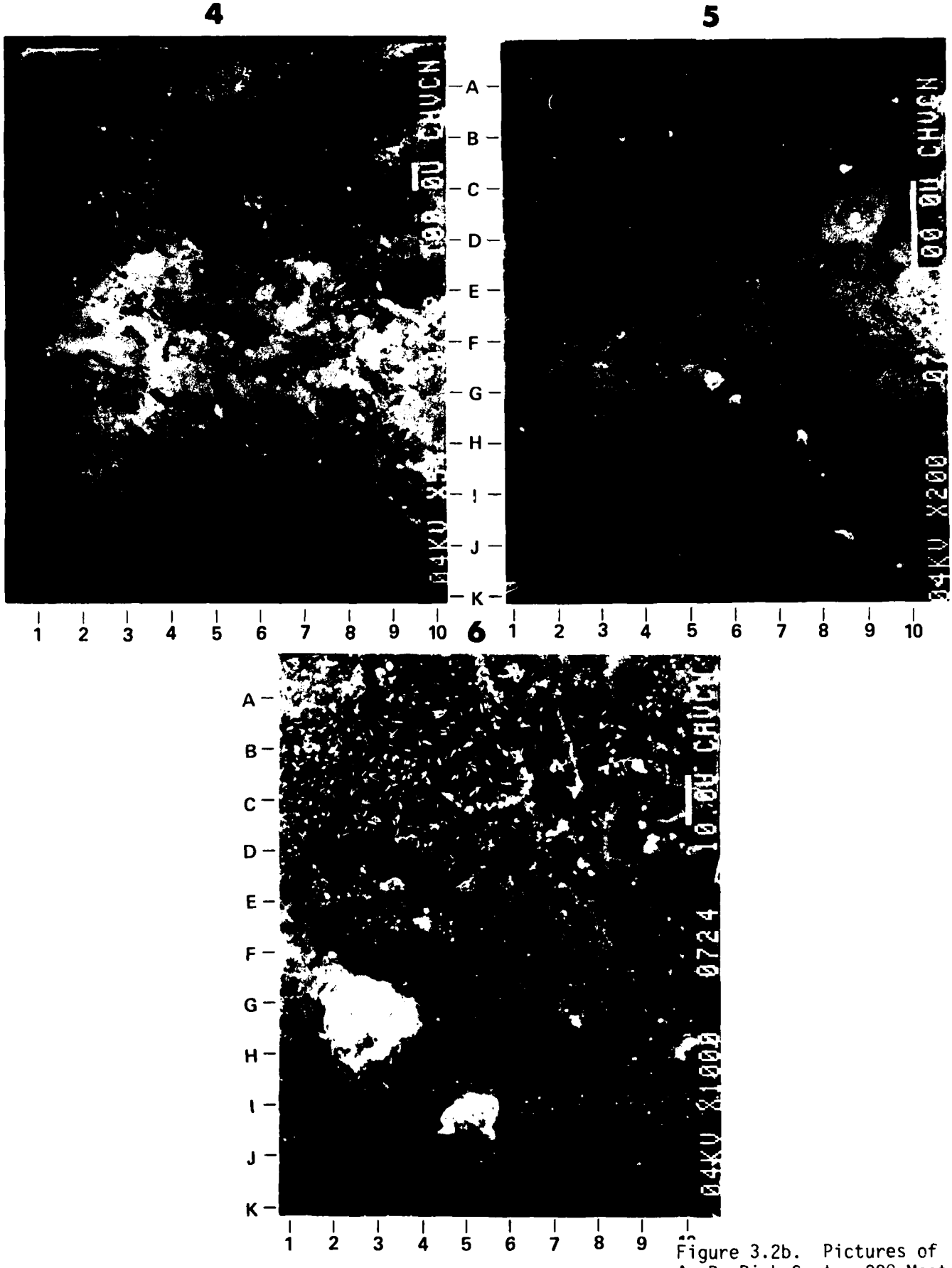


Figure 3.2b. Pictures of A. B. Dick System 200 Master Updatable Microfiche Exposed to Intense Light Prior to Producing an Image.

target from an image on the original microfiche with good resolution and contrast. Picture no. 3 shows film exposed to light under normal operating conditions (the large white spot is a speck of dust used for focusing). Figure 3.2.b are pictures no. 4, 5 and 6 (also taken at magnifications of 54X, 200X, and 1000X, respectively) taken of a different resolution target located in a place on the microfiche where the microfiche was exposed to intense light for several hours before the image was filmed; the D-max of the density target for the image was 0.72. The large white spot on photos 1, 2 and 3 is a dust particle and was used for focusing. It is apparent that photos 1, 2 and 3, made of film with good resolution and without significant exposure to light, have a uniform, fine grain texture at all magnifications. Photos 4, 5 and 6 suggest that some form of major recrystallization has taken place after prolonged exposure to light. Photos 5 and 6 show some portions of the film have retained the uniform, fine grained texture, but that several forms of recrystallization have taken place over most of the film. The white bright spots on photos 5 and 6 appear to be nucleation points, where recrystallization is extreme. With continued exposure to light, it is anticipated that these centers of recrystallization will expand in size and seriously affect the updatability of the film.

The A.B. Dick System 200 updatable microfiche system has enabled the Army to streamline operations and to simplify the maintenance of the OMPF file. While some deficiencies exist relating to the existing system, no other updatable microfiche system nor unitized record system described below, nor any other micrographics system discussed in Chapter 4, offer sufficient advantages over the existing system to warrant conversion. Digital image technology discussed in Chapter 5, however, may offer significant advantages once the technology is perfected.

3.1.2 Alternative Updatable Microfiche Systems

There are two additional updatable microfiche systems available in the marketplace which were considered as part of this project. Both are described below, although neither is recommended to replace the existing system.

(a) Microx. The Microx system, developed by Bell and Howell, is an updatable microfiche system that has been available for several years. The system has the following features:

- The image is "embossed" on the surface of the film.
- Imaging cycle time is approximately 10 seconds or, similarly, 22-27 seconds including document handling.
- The image is erasable by remelting the appropriate image on the microfiche. Approximately 45 seconds is required to erase the image prior to subsequent exposure.

The Microx updatable microfiche system should not be considered by the Army, however, for the following reasons:

- Although the erasability feature is attractive, the feature would only be appropriate to erasing images due to expungement or operator errors. Unless a new image is placed in the same location as the erasure, blank images will result, probably having the same impact to Boards as blacked-out images. In addition, unless the original documents exist or an excellent quality reader-printer copy is produced (generally not possible with the reader-printers currently being used), the erasing feature will not be adequate for resequencing documents. The erasing capability, therefore, only resolves minor problems with the existing A.B. Dick System 200.

- Although a key can be provided to prevent unauthorized erasures, it is still possible to accidentally erase the wrong image.

- The system is incompatible with the A.B. Dick technology, requiring complete conversion of camera-processors.

- The system is no faster than the A.B. Dick system.

(b) Ovonics Series 7000/7010. The Ovonics system has been tested, but not marketed, by several companies over the last eight years. The reasons for the failure of this technology in the marketplace have never been clearly defined. The technology has the following characteristics:

- The film is light sensitive, updatable, but not erasable.

- The cycle time is 7-9 seconds, actually no better than A.B. Dick when document handling is included.

- The model 7010 can accept digital images at 9600 baud (bits per second) by an RS232C interface.

The Ovonics system does not appear to offer any significant advantages over the A.B. Dick system and should not be considered.

3.1.3 Alternative Unitized Microfiche Systems

A unitized microfiche record can be created by at least two methods other than updatable film. Although neither method is recommended in place of the existing system, they are described briefly below for completeness.

(a) Strip-up System. The Navy and the Air Force utilize a "strip-up" system to create their unitized personnel records. This approach and jacket systems were the only ones available to the Air Force in 1972; updatable microfiche was not available commercially until 1975.

A unitized record is produced in the strip-up method from traditional silver halide roll film. Images are filmed in the order received on roll film, with an adhesive backing added. Under computer control, each individual frame is cut from the roll, and placed in the proper grid location of the appropriate microfiche, creating a unit microfiche record. Some of the advantages of this approach compared to the updatable microfiche approach are as follows:

- Errors can be corrected, images can be erased or resequenced without refilming.

- The film used consists of traditional silver halide technology which can achieve archival quality.

- Medium and low contrast film can be utilized to produce an excellent quality reproduction of the photograph.

- Negative microfilm images are utilized which produces negative images with a diazo duplicate (less screen glare when reading) and better quality reader-printer copies.

Several disadvantages exist with this technology:

- Since the resulting microfiche is substantially thicker than the updatable microfiche (due to the thickness of the polyester base. adhesive strip, and microfilm), two to three times more Access-M units would be required for storage of the same number of microfiche.

- Record integrity may be compromised since images are relatively easy to remove and could potentially fall off over time. It is unclear whether the adhesive used in the strip-up process is archival or will last at least 75 years.

- The system is extremely labor-intensive, requiring many more steps and a sophisticated computer control system.

- Conversion to new equipment would be extremely expensive.

(b) Film Jacket Systems. The film jacket system functions somewhat similarly to the strip-up system, except that rather than attaching film images to a polyester sheet, the film images are cut from roll film and inserted into a thin plastic jacket. In most cases, only 60 images can be placed in a 4" X 6" jacket, rather than 98 with strip-up or updatable microfiche systems.

The film jacket system has many of the same advantages and disadvantages of the strip-up system. In summary, however, the advantages don't warrant a switch in technology.

3.2 DUPLICATION

An extremely large number of duplicates are made annually at all four sites. Since users access the OMPF only through duplicate copies, the quality of these copies are extremely important for the success of the entire OMPF system.

3.2.1 Duplicators

There are now two primary manufacturers of high-speed microfiche duplicators in the United States: Photomatrix and Consolidated Micrographics (formerly Bruning). Since the A.B. Dick 200 updatable microfiche is extremely delicate, the original must be manually inserted in the duplicator for duplication,

precluding the use of automatic feeders. When duplication using hand feeding is compared, the relative speeds and quality of these duplicators are comparable.

All four installations utilize the Photomatrix Model 800/820 duplicator with manual feed. While poor quality duplicates are often produced, the problem lies more with the diazo film utilized, the lack of quality control procedures, and improper temperature settings on the duplicators, rather than a problem with the duplicators themselves. For the Xidex diazo duplicate film now being used by the Army, the duplicator temperature should be set at 170°F (or the temperature which produces the best results). In most cases, the installations have been using temperatures up to 195°F, resulting in poor quality duplicates.

3.2.2 Duplicate Film

There are three types of duplicate films available: diazo, vesicular, and silver. The Army currently uses diazo duplicates exclusively. Vesicular film might be considered, especially for Boards, in order to reduce the brightness of the screen image.

(a) Diazo Film. The A.B. Dick original microfiche consists of a positive image--dark characters on a light background--similar to paper documents. Diazo duplicates preserve the same positive image as the original. This type of duplicate film has been used since the inception of the OMPF microfiche project, primarily because the image on the screen appears similar to a paper document, generally, resulting in greater user acceptance.

The major advantages of diazo duplication film are as follows:

- Extremely high image quality, when properly prepared
- Extremely scratch resistant
- No darkroom requirements
- The American National Standards Institute (ANSI) in PH 1.60-1979 established the standard for the preservation of photographic records on film for a minimum of 100 years when stored under "archival" conditions, provided that the original images are of suitable quality. It is believed that black dye diazo film can achieve this standard. This period should be sufficient for the retention of Army personnel records.

Some disadvantages of diazo film are as follows:

- The exposure speed for diazo film is typically slower than for vesicular and silver.
- The development process for diazo film requires ammonia. Although the use of ammonia for duplication is relatively safe, ammonia leaks can result and can be dangerous. Ammonia fumes were detected in some installations visited. OSHA now enforces Regulation 1910.1000 (1968) which establishes an exposure limit to ammonia at 50 ppm (parts per million) over 8 hours. In the future, the agency will support a limit of 25 ppm over 8 hours as recommended by the American Conference of Government and Industrial Hygienists.

Regardless of the type of diazo film being used at an installation, several problems were observed which relate to the poor quality duplicates being produced.

- The D-min for duplicates now being produced range from .2 to as high as .48. While it is expected that some D-min or background density will be apparent for positive images, both Xidex and Novamedia specifications indicate a D-min of no more than .05. Originally it was believed that the high D-min resulted from the high D-min of the A.B. Dick original (.3 to .48). Later it was determined that the high duplicator temperature (up to 195°F) was primarily responsible.

- In order to maintain contrast with the high D-min now appearing in the system, the D-max was also raised to the limit of the film's capacity. When the D-min is too high, the image quality suffers as small characters are filled in, similar to when too much toner is used in a paper copier. Photographs, particularly those of dark skinned individuals, lose their depth and definition when the D-max is too high. Again, high duplicator temperature could be responsible.

- Some of the duplication problems may be related to the age of raw diazo film stocks. With time, the D-max of most diazo film will reduce substantially from original vendor specifications. This could result in reduced contrast during the duplication process.

- It was determined that the duplicator temperature was being set much too high for the duplication films being used. When the duplication temperature was reduced to 170°F, as recommended by the Xidex representative, extremely good quality diazo duplicate images were produced.

- No installation had developed an effective inspection quality control system for duplicate film. As such, users often receive poor quality duplicates which subsequently creates problems with readability of images and acceptability of the OMPF microfiche system.

During the course of the project, samples of Novamedia diazo duplicate film were compared with those of Xidex. The following conclusions were reached during these tests:

- Good quality duplicates can be produced from both the Xidex and Novamedia duplicate films, provided that the Photomatrix 800 duplicator is adjusted properly for temperature and speed.

- The black dye diazo duplicate (either Xidex DEM II or Novamedia BK-1) produce good contrast images and may qualify for the ANSI one hundred year standard. Black dye diazo film is preferable to blue.

The Army should periodically review their duplication film. Samples from various vendors should be tested and compared. The duplicate film selected should produce the best quality image at a good (not necessarily the least

expensive) price. Good quality duplicates are particularly important for producing backup, security copies.

(b) Vesicular Film. The major drawback with diazo duplicate film is the fact that it produces an image with the same polarity as the original, i.e., positive duplicate from positive original. The results of the Board questionnaire discussed in Section 2.2 indicate that Board members are suffering from eye fatigue. The bright light emanating from the background of the positive image may be a source of the discomfort, although the questionnaire indicates that the light may not be the cause. This should be confirmed by a test.

Vesicular film is a polarity reversing film which would result in an image with light letters on a dark background. Some of the benefits of a negative image are as follows:

- Most studies have shown, and users confirm, that a negative image results in less eye strain compared to a positive image, especially when a reader is used for long periods of time. Most CRTs, scoreboards, and automobile instrument panels utilize negative images for this purpose.

- Most reader-printers produce better quality positive prints (black letters on a white background) from a negative image than from a positive image.

While vesicular film offers some advantages for users such as Boards, there are some negatives which must be considered.

- The resolution of vesicular film is substantially less than diazo or silver. Although lower resolution may not be discernible to the human eye, it may make a substantial difference in viewing images where the original document was of marginal quality.

- The vesicular film has a tendency to fade over time if the exposure time was too short or temperature too low. This is not a major problem since the fiche will be used a short time after being produced and new duplicate copies can be readily prepared.

- The film is much softer than diazo and susceptible to scratching and damage.

(c) Silver Film. Silver duplicate film was never seriously considered by the Army, although it will generally produce a better quality duplicate and better paper prints. Silver film is generally not recommended for duplication due to high costs and potential damage to the image through scratching. Silver duplicates of the original OMPF microfiche may be required in the event that the testing of the A.B. Dick updatable microfiche proves that images are fading over time. If archival quality duplicates are required, however, black dye diazo duplication film may meet the ANSI 100 year period.

3.3 MICROFICHE READERS

Microfiche readers are required to read the duplicate microfiche provided. Some users, especially Boards, spend a great deal of time reading microfiche on a reader; Board members may review up to 200 individual records per day for several successive weeks. Consequently, the microfiche readers provided to users should be of the highest quality and provide features to facilitate use.

Some of the desired characteristics of the microfiche reader include the following:

- Rear projection screens should generally be used since they bring the image closer to the user. Some individuals, however, have complained about eyestrain and body fatigue resulting from sitting in front of a rear projection screen all day. In addition, individuals wearing bifocals have particular problems since they must tilt their head backwards. As such, it may be appropriate to provide individuals with an option of using readers with front projection, to enable them to maintain a more comfortable sitting position.

- Dual page display should be provided so two pages, or the front and back of one document (such as the evaluation report), can be displayed simultaneously.

- The magnification ratio of the reader should produce an image which is the same size as the original document.

- High quality optics should be provided for crisp images, from corner to corner of the screen.

- Image rotation should be provided to allow easy viewing of diplomas, certificates, and other documents filmed in cine mode. Light intensity or brightness should be adjustable to enable the user to select the most comfortable level of illumination.

- Dual carriers should be provided to allow easy viewing of records requiring more than one fiche.

- Microfiche carriers should operate smoothly with minimal fingertip effort, yet remain motionless when released.

- Fanless cooling systems are preferred since they are quieter and have less vibration.

- Focusing should be easy and precise. The reader should have a floating lens to hold the focus at all parts of the microfiche.

- A dual lens capability should be provided to enable sections of the image to be magnified for closer inspection; this is particularly important for poor quality images.

- A screen hood should be provided to reduce glare from overhead lights.

- All electrical and optical components of the system should be in a drawer ("works in a drawer") to minimize down time and to facilitate maintenance and cleaning.

- The microfiche carrier should open automatically to facilitate loading and unloading of microfiche.

- All controls (focus, brightness, etc.) should be conveniently placed near the front of the reader.

While the above features are desirable, it is recognized that costs for readers having all these features may be prohibitive, considering the large volume of readers used by the Army. Special consideration should be given, however, to those users who need the reader for long periods of time, and they should be provided with the greatest number of capabilities possible.

In addition to reader features, an ergonomic work station should be provided (see Figure 3.3), especially for Boards, since they read the microfiche for long periods of time. Some characteristics of an ergonomic work station include the following:

- Chairs should be adjustable in terms of height and back support.

- The reader stand should be adjustable in terms of height to enable the user to sit comfortably with the top of the screen at eye level.

- The reader should be placed on a device which tilts and swivels to enable the user to determine the most comfortable position. Tilt is particularly important for those who wear bifocals.

- The desk or other work surface provided should be 29" high and provide sufficient space for all major activities to be performed.

3.4 MICROFICHE READER-PRINTERS

Reader-printers are used to provide paper prints of the microfiche image. A high volume of paper prints are produced particularly at RCPAC and NPRC in response to requests for copies of the DD-214 and other documents related to separation from the Army. While some installations use Cannon Model 370 reader-printers, NPRC and others use 3M 800F dry silver reader-printers. The former produces positive prints from a positive image, while the latter produces negative prints from a positive image.

Reader-printers should have the following features:

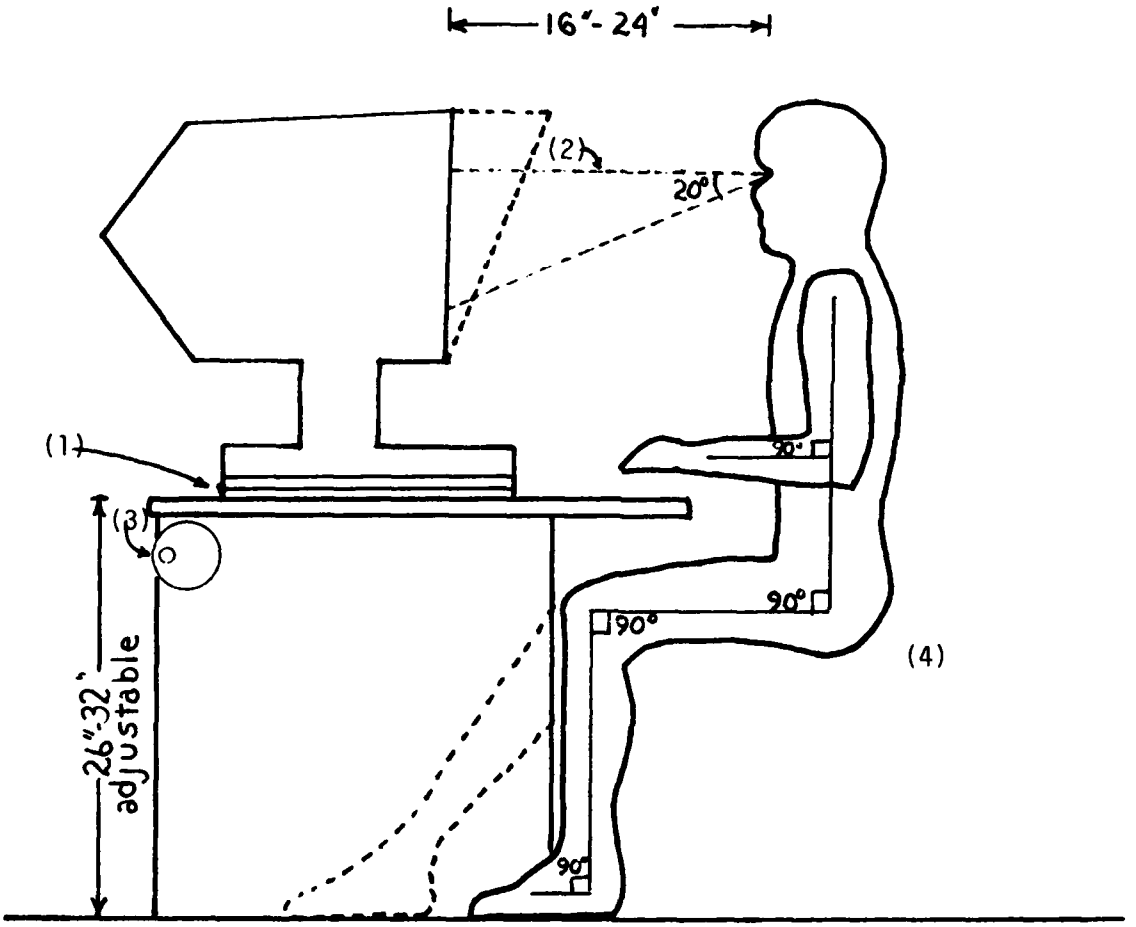
- Capability of producing a positive print from either a positive or negative image. A positive print is more acceptable to the general public than a negative one and generally easier to use.

- Automatic exposure control to prevent poor quality prints or wasted prints.

- Fast warm-up capability so that the first print produced is acceptable.

Figure 3.3

ERGONOMIC MICROFICHE WORKSTATION



(1) Reader should be on a stand which:
-rotates 360°
-tilts 10°- 15°
(2) Top of image should be at eye level.
(3) Surface on which reader stands should be crank adjustable.
(4) Chair should have these features:
-swivel 360°
-5 legs, with casters
-waterfall front
-firm foam construction
-adjustable seat height, back height and back support.

- Plain paper prints are preferred to coated paper. While the costs per print for dry silver and coated paper prints are $.10 to $.15, the costs for plain paper copies are $.03 to $.05. Plain bond paper reader-printers, however, are much more expensive. The plain paper print is much higher quality and more acceptable to the users.

Since only a few reader-printers are required, it is suggested that high-quality reader-printers be obtained in order to provide high quality paper prints when necessary.

3.5 COMPUTER SYSTEMS

Each installation maintains a computer system to identify the Access-M number for each record and to perform other tasks. The computer systems at the National Guard and RCPAC can directly control retrieval of records from the Access-M units. The National Guard is equipped with the Automatic Delivery System which will enable a specific carrier to be ejected from the cartridge into a separate bin. The combination of computer-assisted retrieval and automatic ejection of the carrier may represent an improvement in productivity, especially for retrieval of records for Boards.

Information is transferred between sites, and between a site and the SIDPERS system, through an exchange of magnetic tapes. This process is generally slow and cumbersome, and direct access to information in other computers is now impossible. Much more computer system integration is needed.

RCPAC also suffers from the lack of programming staff to modify and enhance system software capabilities. As such, many functions which would substantially improve the total microfiche system operation have not been implemented. Even if software capabilities were improved, the existing computers may not be able to perform adequately.

CHAPTER 4. ALTERNATIVE MICROGRAPHICS SYSTEMS

This chapter reviews the alternative micrographic systems available to the Army for the management of personnel records. Chapter 5 will review a substantially different technology, digital image technology, which may offer solutions to resolve problems with the existing micrographics system. Chapter 6 will present an analysis and comparison of the major alternatives presented in this report.

In 1975, the RAM2 Committee evaluated all the available imaging technologies. The selection of the current updatable microfiche with automated retrieval equipment represented the state of the art for that time. Since then, a number of vendors have developed advanced micrographics systems, some including the capability of digitizing micrographic images and transmitting them electronically. These so-called "transition technologies" serve as a bridge between the manual microfilm systems of the mid-1970s and the digital image technology systems expected for the mid-1980s. As the analysis suggests, rather than incurring the large cost of conversion to a mere transition system, the Army can most effectively automate the personnel records system by improving the existing micrographics system and converting to the new digital image technology in the future, when appropriate.

4.1 FACTORS FOR CONSIDERATION

Three major factors help distinguish between the four categories of micrographics systems described in the chapter: file organization, method of retrieval, and method of dissemination/use. Figure 4.1 describes the advantages and disadvantages to the Army personnel system for each of these factors.

4.1.1 File Organization

The file itself can either be organized as a unit record or random access system. A unit record system consists of all images or documents related to a single personnel record maintained together. This is currently being achieved using the updatable microfiche technology. A random access system would consist of images or documents related to a personnel file maintained on perhaps many different rolls of films or microfiche since all images in the system are filmed chronologically on the next available frame in the system. Indexes are required in a random access system, to locate the roll or microfiche and frame number. Substantial time may be required to retrieve all frames related to an individual record.

As a practical matter, the ideal micrographics system would include random filming for updating the personnel file, combined with unit record retrieval of the file. The combination of these two factors, however, cannot practically be achieved through existing microfilm systems.

4.1.2 Method of Retrieval

The retrieval method consists of two components: the method used to locate the particular roll or microfiche and the method used to locate the specific

Figure 4.1 Comparison of System Factor for Micrographic Systems

	Advantages	Disadvantages
File Organization		
Unit Record	Fast retrieval for entire record	Original must be retrieved for updating
	No indexing required (except once for entire record)	Difficult or impossible to purge or resequence individual images
	Entire microfiche record can be purged rapidly	Incoming paper documents must be sorted
		Images must be scanned visually to locate desired ones
Random Access	Filming is faster	Retrieval of entire record extremely slow
	Image locations related to a record can be purged or the order resequenced by the changing index	Indexing required for each document filmed; index required for retrieval
	No sort required for incoming paper documents	Difficult or impossible to physically purge entire record from the roll or microfiche
		Microfilm storage requirements grow with time
Method of Retrieval		
Manual	Low equipment costs	High degree of human intervention
	Few mechancial problems	High personnel cost
		Slow retrieval
		Increased probability of error
		Potential damage to microfilm

Figure 4.1 Comparison of System Factor for Micrographic Systems

	Advantages	Disadvantages
Retrieval Method (cont.)		
Automated	Reduced human intervention	High equipment costs
	Lower personnel cost	High probability of mechanical problems and down time
	Faster retrieval	
	Low probability of machine errors	
	Low potential for damage to microfilm	
Method of Image Presentation		
Optical	Low cost equipment	Duplicates must be made for use
	High quality image	Duplicate quality less than original
		Multiple access to records requires multiple duplicates
		Contention problem for master--may be out of file for update or duplication when record requested
		Slow access
Digitized/Electronic	Fast access	Reduced quality image (unless enhanced)
	Multiple access	Expensive equipment
	High level of accuracy	Potential for electro-mechanical failures
	Original never out of file	Requires high speed image transmission rate
	Original can be updated while being read	
	Less human intervention	
	Duplication not necessary for dissemination	

image. The more sophisticated systems utilize computer control in conjunction with electromechanical devices to locate the specific media and position the roll or microfiche to the appropriate image. The less sophisticated devices require some degree of manual intervention. Ideally, once the image has been captured, the storage and retrieval system should enable the user to automatically locate both the roll or microfiche and the image, without any human intervention in the process.

4.1.3 Method of Image Presentation

The method of image presentation or display will vary based upon the sophistication of the system. Manual systems will utilize optical projection systems to enable users at a particular work station to view the image. More sophisticated systems will digitize the microfilm image, transmit the image to a remote location, and display the image on a high resolution graphics terminal, COM device, or laser printer. The more sophisticated devices therefore do not require the use or handling of the microfilm by the end user, permitting multiple access, faster retrieval of information, and security for the system.

4.2 CLASSIFICATION SYSTEMS

In order to simplify the review of alternative micrographics systems, four classifications have been developed:

- Manual microfilm system
- Computer-assisted retrieval (CAR) systems
- Automated document storage and retrieval systems (ADSTAR)
- ADSTAR systems plus digitized image transmission

Most systems now available in the marketplace fall into one of these four categories, each category having specific characteristics which distinguishes it from the others. Since all systems can be configured in a variety of different ways, cost comparisons are extremely difficult. Figure 4.2 compares the automated micrographic storage and retrieval systems.

4.2.1 Manual Microfilm Systems

Manual microfilm systems have been in existence since the 1920's. They include the traditional roll film or microfiche systems managed without computer control. Under most circumstances, records are microfilmed either in some predetermined sequence (such as chronological or numerical order) or as a unit record (such as an inactive case file). Indexing is generally performed by scanning images on the microfilm until the desired image is located and displayed on the reader.

The manual equivalent of the current micrographics system would consist of updatable microfiche with trays, drawers, or shelves used for manual storage. Personnel costs would be substantially higher with this approach, however, due to increased time for retrieval and refiling of information, lost and misfiled records, and greater movement of personnel within the system. As such, this approach represents a step backwards for the Army and should not be given serious consideration.

Figure 4.2 Comparison of Alternative Micrographic Storage and Retrieval Systems.

	Computer-assisted Retrieval (CAR)	Automated* Document Storage and Retrieval System (ADSTAR)	ADSTAR plus Digitized Image Transmission
Companies	Kodak KAR-4000 3M Micrapoint Bell & Howell Several others	A.B. Dick System 200/Access M	Ragen 1010 Image Systems 6000 Access 2010
Microform	Roll film--blip encoded in cartridges	Updatable microfiche in coded carrier	Roll film--blip encoded in cartridges microfiche--with coded strip
File Organization	Random access	Unit record	Random access
Retrieval Method - to Locate Microform - to Locate Image	 Manual Automated	 Automated Manual	 Automated Automated
Image Display/ Transmission	Optical	Optical	Electronic/ digitized image

*Existing System

4.2.2 Computer-Assisted Retrieval (CAR) Systems

CAR systems include the traditional preparation of the microfilm, indexing of each individual frame, and computer assistance in locating the proper roll and frame location. Most CAR systems utilize 16mm roll film stored in cartridges with blip encoding. Microfilm cartridges are maintained in a variety of different types of manual storage equipment. Images are retrieved by first accessing the index to determine the proper cartridge, manually loading the cartridge into the automated reader, and utilizing the capabilities of the automated reader to locate the appropriate frame number. Manual intervention is required to retrieve specific cartridges, but specific frames are retrieved under computer-assisted control.

Since most systems utilize roll film, documents must be microfilmed in order of receipt. Many cartridges may therefore be retrieved to locate all documents related to a specific personnel record. If the entire personnel record is required, paper prints must be made, since it is not practical to create a microfilm duplicate containing the selected images constituting a complete record. This approach functions contrary to the unit record requirements for the Army's personnel records.

Conversion to a CAR system is therefore not recommended for the Army personnel records.

4.2.3 Automated Document Storage and Retrieval (ADSTAR) Systems

The existing system may very well be described as an "automated document storage and retrieval system" or ADSTAR system. The primary characteristic of these types of systems is that the media can be retrieved by an automated storage unit under computer control. The existing Access-M units, for example, will retrieve an entire personnel record when the correct M-address is entered at the keyboard or specified by the computer command.

The existing system, however, qualifies at the low end of ADSTAR capabilities. Once the microfiche record has been retrieved, the carrier must be manually removed from the M-unit (or automatically ejected if the Automatic Delivery System is being used), physically transported by staff, and duplicated prior to use. The user of the duplicate must scan the microfiche to determine the appropriate image for review. As such, the system offers automated retrieval of the media, but manual location of a particular image.

The microfiche are maintained as a unit record. Every time updates are required, the unit record must be retrieved, updated, and then returned to the storage unit. Substantial personnel time is required for updating these records.

The problems of the existing system have been reviewed in depth in Chapters 2 and 3. With enhancements, the existing system can continue to function effectively for several years until more sophisticated technology becomes available.

4.2.4 Automated Document Storage and Retrieval Plus Digitized Image Transmission (ADSTAR+DIT) System

These systems can truly be viewed as the "transition systems" because they combine image storage using microfilm with electronic transmission of digitized images--storage methods from past and current systems and image transmission methods being developed for future systems. The combination offers a great deal of advantages not found in the existing system or other alternative micrographics systems. Some of the advantages include multiple access, automated media and image selection, transmission of images to remote locations, and rapid access to images.

The cost of these systems and the time to assemble a complete personnel file represent significant drawbacks to this technology. The cost is estimated to exceed the cost presented in Chapter 5 for digital image technology in the areas of both personnel and equipment. The roll film version of an ADSTAR+DIT would require very rare and expensive equipment to convert the image from microfiche to roll film. The microfiche version of the ADSTAR+DIT system would be more expensive because of the number of units required, e.g., over 100 ($2.5 million) at MILPERCEN and almost 700 ($15.5 million) at EREC. Additionally, the time required to assemble records for Board review could approach ten times the time required for the existing system.

4.3 SELECTED SYSTEM DESCRIPTIONS FOR MICROGRAPHIC-BASED TRANSITION TECHNOLOGIES

The project staff reviewed a number of different micrographic systems being classified as "transition technologies" by the micrographics industry. These systems generally have the following characteristics:

- Microfilm (either roll film or microfiche) is used as the primary storage media.
- An electromechanical device or autoloader is utilized to automatically retrieve the microfilm media without human intervention.
- The image is scanned, digitized and transmitted electronically to a work station.

The following is a brief description of some of the micrographic-based transition systems reviewed during the course of the project:

- Teknekron AMARS System. This represents one of the first of the transition technologies developed and was pilot tested in 1980-1982 by RCPAC. The AMARS unit consisted of a linear electromechanical device which retrieved microfiche from a tray, scanned the microfiche, and transmitted the image to high-resolution graphics terminals in the Career Management Branch. The system failed to function as expected due to mechanical problems, poor image quality and the requirement that duplicates be made from the updatable microfiche original. This system has apparently worked successfully, however, at installations for Texaco and the Government of Saudi Arabia.

- TERA Corporation. TERA Corporation is a subsidiary of Teknekron, serving as systems integrator for transition technologies. They currently market a variety of computer-assisted retrieval plus digital image transmission systems using the microfiche retrieval unit developed by Image Systems.

- Image Systems ISI 6000. Image Systems markets directly and distributes OEM versions of the primary automated microfiche carousel retrieval unit used in the micrographics industry. Each carousel holds 780 fiche attached to specially encoded edge-notched metal strips used for retrieval; the unit provides a capacity of 76,000 images at 24X or 421,200 images at 72X filmed in random order. Images from different microfiche can be retrieved in approximately 10 seconds, compared to approximately 1 second for adjacent images. It is estimated that approximately 120 ISI 6000 units would be required initially to store 100,000 officer records and that additional units would be required in the future since purging from active microfiche is almost impossible.

- Ragen 1010 Information Management System. The Ragen 1010 system utilizes blip encoded roll film housed in proprietary cartridges, and retrieves utilizing an electromechanical device. Images are randomly filmed and are retrieved utilizing a computer index. Ragen claims a storage capacity of 1.2 million pages per storage unit (300 cartridges, holding 4000 images each at 25X) with a typical access time of less than 10 seconds per page. A paper printer is generally used to display images, although high resolution terminals could also be used; the user has the option to accept the paper print or remove the ink and reuse the paper for the next image.

- Access 2010 System. Access Corporation has announced and is demonstrating a new version of its ADSTAR System. The storage device locates the desired image under computer control, retrieves the microfiche, locates the image, digitizes the image, and transmits the image. These tasks are performed without human intervention. As a practical matter, this unit will not work with the A.B. Dick updatable microfiche originals since (1) the originals must be maintained in a protective carrier and no method exists to automatically remove the original from the carrier and (2) storage requirements would be excessive if one original was stored per carrier.

- Mnemos System 6000. The Mnemos system provides the operator with a self-contained, stand-alone system for retrieving images and data. The system utilizes a specially designed plastic disk which maintains up to 6000 images and digital information in analog format. Disks may be interchanged by the user, but a juke box configuration is being considered by the manufacturer. Disks must be specially manufactured using a glass original from which plastic disks are stamped using a duplication method similar to the production of phonograph records.

None of the micrographic-based transition technologies reviewed warrants serious consideration to replace the Army OMPF updatable microfiche system. Several vendors marketing micrographic-based systems with or without digital image transmission are hoping that existing clients will retain current systems and that new clients will be attracted to their micrographics-based product line, instead of completely converting to the new digital image

technology. While this strategy may make good marketing sense for the vendors, the Army would be well advised to wait a few short years since digital image technology appears to offer substantial benefits not attainable by either the current system or these transition technologies. Since the current system continues to function and can be enhanced according to the recommendations made in this report, there is little justification to incur the large conversion cost to these transition technologies at this time and then convert again in a few years to a digital image system.

4.4 CONCLUSION

In summary, neither the computer-assisted retrieval nor the automated document storage and retrieval systems, with digitized image transmission, offer significant benefits over the existing system; they also present significant disadvantages when compared to the newly emerging digital image technology. It is recommended that no other micrographics-based technology be developed for the Army's personnel records.

CHAPTER 5. DIGITAL IMAGE TECHNOLOGY

5.1 INTRODUCTION TO DIGITAL IMAGE TECHNOLOGY

During the last few years, much has been written and discussed regarding the prospect of the "electronic filing system." A number of vendors have developed systems which they called "electronic," but in reality proved to be microfilm storage systems with computer-assisted indexing and retrieval, such as the micrographics technologies discussed in the previous chapter. Until 1983, no company had marketed all components necessary for the total electronic filing system.

Beginning in 1983, significant developments occurred which marked the emergence of the still infant technology now referred to as "digital image technology." For several years, engineering drawings and maps have been digitized (converted to computer-readable format consisting of a series of dots or pixels to represent the image) in order to permit computer processing of the information and revisions of the images. Images are digitized manually, by tracing the outline of an image with a "mouse" which communicated electronic signals to the computer. The process is time consuming. In 1982, vendors began offering scanning equipment and appropriate computer software for digitizing. Although similar scanning technology has been used for several years in the microfilm-based transition technologies to digitize and transmit images electronically to remote locations, no vendor was actually utilizing scanners to digitize and store large data bases.

Equally important, 1983 marked the introduction of the first commercially available optical disk systems (Thompson-CSF and Drexler Technology Corporation) and the demonstration of a number of prototypes (Sony, Storage Technology, and others). Due to the large storage requirements of digitized information, existing magnetic storage media is considered inadequate for the storage and maintenance of large image data bases. Optical disk provides a low cost, highly accurate method for storing huge volumes of information, including images, in a relatively compact space. The first juke box was developed by Integrated Automation for a pilot project conducted for the Library of Congress; the storage capabilities of a juke box holding 100 or more optical disks creates the potential for the management and storage of an almost unlimited volume of digitized images.

During the next few years, it is expected that a number of pilot projects and operational systems will be developed to meet pressing needs in both government and industry. Many of the unanswered questions related to this technology will hopefully be resolved during this period. While the Army can wait at least a few years before converting to such a technology, the concerns and problems with the existing updatable microfiche system will continue to grow during this same period. The Army should carefully consider the great potential of this new technology and begin plans for a pilot project, followed by the conversion to operational systems for all Army personnel records.

This chapter provides a basic description of digital image technology and presents a number of issues for consideration. Much more analysis and design work is required before the Army can effectively develop its own system. This chapter, however, should serve as a basis for assessing the state-of-the-art

and provides a review of some of the innovative applications of this technology for personnel records developed by the project staff during the course of this project.

Digital image technology includes some terms and concepts different than those used in either micrographics or data processing. The Glossary contains some definitions which the reader may find helpful.

5.2 SYSTEM COMPONENTS

The following section describes the five major components of a digital image system:

- Image Capture
- Storage/Optical Disk
- Image Transmission
- Image Presentation
- Computer System

Within each section, problems and concerns related specifically to the Army's personnel records are discussed.

5.2.1 Image Capture

Image capture or scanning is the first step in converting documents into a digital format. This step may be compared to image capture using a microfilm camera. After image capture, however, images in digital format are handled substantially differently than those in micrographic format.

(a) Background. Early efforts in scanning utilized laser technology. Most recent scanners, however, use a charge coupled device (CCD) since it provides higher scanning speed, increased resolution, and better flexibility than laser technology. Most American companies and many Japanese companies are using a CCD array from Fairchild Semiconductor; some companies are using a CCD array from Nippon Electric Company (NEC), which offers high resolution but slower scanning speed.

While microfilm technology forms an image by hardening silver halide emulsion (traditional microfilm) or using liquid toner on a photosensitive base (updatable microfiche), a scanner records an image by converting the document to a series of discrete points or pixels (contraction of the words "picture elements"). A CCD scanner will measure the degree of lightness or darkness of each pixel and assign it a numerical value. If the system is designed to recognize gray scale, then up to 256 different levels of gray can be detected; otherwise, if the system is bitonal (either white or black) a threshold is set to determine which pixels will be considered white and which black. The results are then stored in the computer in binary format (one bit for a bitonal system and generally three to eight bits for recording gray scale).

(b) Gray Scale. The scanning systems used for Army personnel records will probably be equipped to identify up to eight levels of gray scale, requiring three bits in binary format to represent each pixel. This

will result in capturing more of the fine definition for each document. Image enhancement techniques (see Section 5.4.2) can then more effectively be applied to improve the image and later convert each pixel representation to one bit per pixel. If the eight levels of gray scale were permanently stored within the system, three times more optical disk storage would be required than if the same image was processed and enhanced and then stored in bimodal form.

(c) Resolution. The Fairchild CCD array can identify 1,728 discrete points or pixels along the width and 2,048 pixels along the length. A letter-size page would then be converted into 3.74 million pixels (or 3.74 million bits in bitonal form and 11.22 million bits with 8 levels of gray scale). Each square inch of the document is scanned at 200 X 200 pixels, or a resolution of 200 pixels per inch (also referred to as 200 dots per inch or 200 lines per inch). Other CCD arrays can scan 300 or more dots per inch.

In micrographics, resolution is stated in terms of observable line pairs per millimeter. Resolution may range from below 100 lp/mm for rotary cameras to over 1,000 lp/mm for laser COM devices. A higher resolution is extremely desirable because it produces a sharper, clearer image. In digital image processing, a resolution of 200 dots per inch is considered standard. Many Japanese vendors scan at 300 dots per inch in order to adequately resolve the Kanji character set; the Library of Congress will scan at 300 dots per inch to capture fine detail. A resolution of 300 dots per inch will generally be used throughout this report (although the Army may consider a resolution of 200 dots per inch, provided the image quality is adequate).

While increased resolution in micrographics has no undesirable characteristics, increased resolution in digital image processing is obtained at a significant price. Figure 5.1a below shows the impact of increasing the resolution for scanning a letter-size document and its impact on storage of the image.

Figure 5.1a Impact of Scanning Resolution on Storage Requirements.

Resolution (dots/inch)	Storage Requirements Bimodal (1 bit/pixel)	Storage Requirements Gray Scale (3 bits/pixel)
50	233,750	701,250
100	935,000	2,805,000
200	3,740,000	11,220,000
300	8,415,000	25,245,000

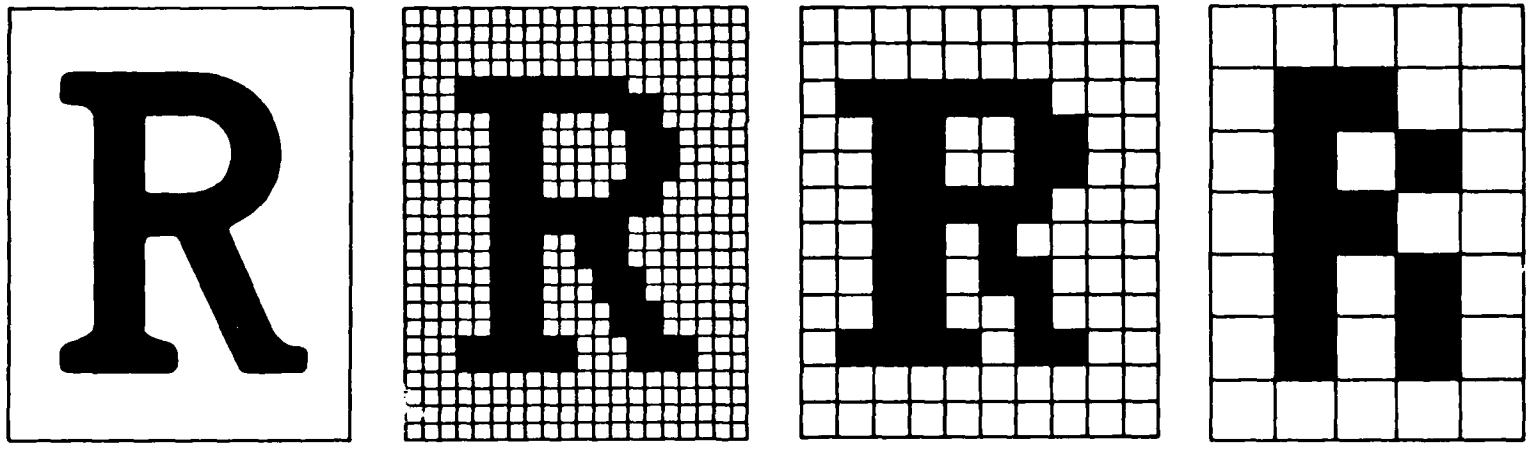
The resolution used within a digital image system must therefore be a compromise between desired image resolution (and gray scale) and optical disk storage requirements. Figure 5.1.b shows the impact of higher resolution on image quality.

5.2.2 Data Storage/Optical Disk

One of the major limitations that has slowed the progress of digital image technology is the massive storage requirements for digitized images. The micrographic-base transition technologies utilize CCD scanners to transmit images, but continue to use microfilm as the storage media, partially due to

Figure 5.1b

SCANNING RESOLUTION



TYPESET | 200 DOTS PER INCH | 100 DOTS PER INCH | 50 DOTS PER INCH

DRAWING: COURTESY EASTMAN KODAK COMPANY

the storage requirements. For years, the data processing industry considered a 100 megabyte disk as providing a substantial amount of magnetic storage; in fact, it could store only 95 unprocessed, digitized images of letter-size pages at 300 dot/inch resolution. Clearly, an alternative approach was required. Three options exist to increase the document storage capability: (1) decrease resolution, (2) decrease or "compress" the amount of storage required per image, or (3) increase the capability of the storage media. The first option is unacceptable since it adversely impacts image quality; research has, therefore, centered on achieving acceptable storage density and costs by compressing information and using optical disks.

(a) Data Compression/Decompression. Data compression techniques seek to reduce or compress the amount of data required to represent a stored image; data decompression expands the stored image to recreate the appearance of the original image on output. The primary method used today for data compression is called run length encoding (RLE). RLE compresses digitized images by reducing the amount of information used to store the bit pattern representing the image. (See Figure 5.2.)

During a typical scan of a page at 300 dots per inch, the scanner examines approximately 2,550 pixels along the width (by 1 pixel wide). If the entire line is blank, or white, and no gray scale recorded, the system would store 2,550 identical "0" bits (0000...000 until 2,550 0's were recorded). With RLE, the system identifies identical bit patterns within the scan line and records the information in compressed format; for example, the number 2,550 would be stored to represent the 2,550 "0" bits rather than repeating "0" 2,550 times in storage. "Bit plane" RLE refers to compressing the image in both the horizontal and vertical directions (X and Y axes) to achieve the maximum compression.

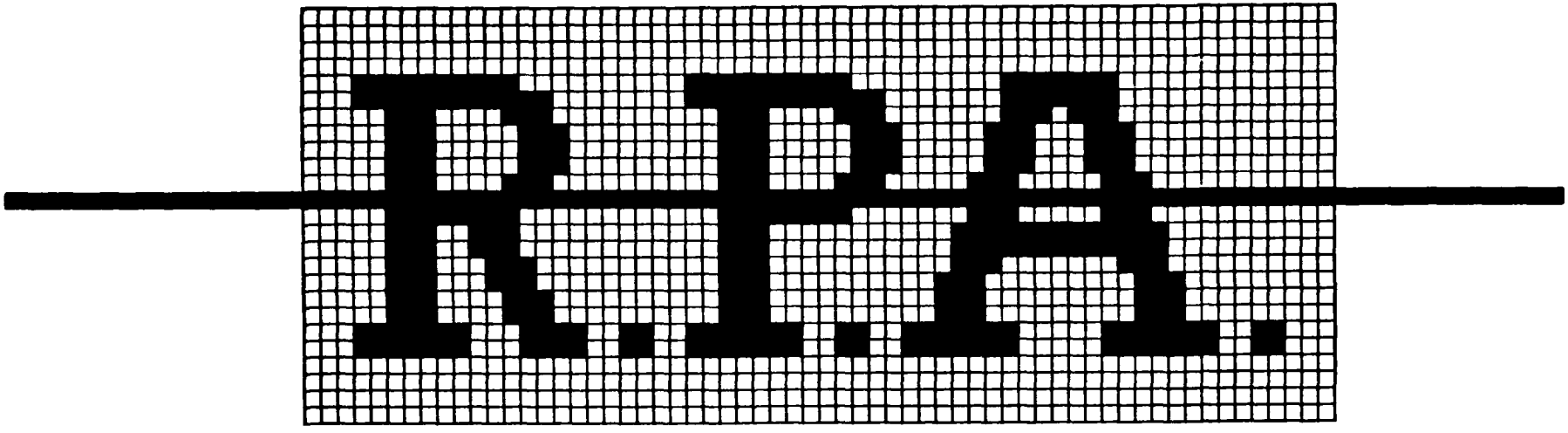
The degree of compression achieved depends on the type of information scanned. Documents containing a great deal of text and information will be compressed much less than those containing a great deal of white space. Using standard data compression protocols such as CCITT Group 3, data compression rates of 5:1 to 20:1 are possible, with 10:1 being the average. At 10:1 compression ratio, 841,500 bits or 105,188 bytes would be required to store a typical document image at 300 dots per inch. In the first systems developed, data compression was handled within the computer system. With present day scanners producing output at a rate of 20 million bits per second (20Mhz), and most computers accepting input at less than 10 times that rate, serious problems developed. Newer systems will therefore compress data at the scanner, transmit the compressed data to the computer, store the compressed data on optical disk, transfer the compressed data to the output peripherals, and decompress the data to original appearance at the terminal or printer. This will permit information to be transmitted through the system at much higher rates than would otherwise be possible. The compression/decompression operation will become a peripheral function, but the benefits of compression will result in reduced computer storage requirements.

(b) Optical Disk. Even with the use of compression techniques, a typical 100 megabyte magnetic disk could only hold approximately 950 documents at 300 dots per inch. The largest magnetic disk made would hold approximately 9,500 documents but cost about $100,000; when the disk was full, ar additional disk drive would be required. The need for an alternative storage media has been apparent for several years.

Figure 5.2

COMPRESSION

(RUN LENGTH ENCODING)



Pixels

Counting redundancy and compressing

5 8 12 8 7 3 5 3 11

Beginning in early 1970, a number of vendors began development of a high capacity optical storage device. By 1982, the first commercially available optical disks were being utilized in systems. In 1983, over 30 different manufacturers are at one stage or another of optical disk media and disk drive system development. Prices for optical disks range from $100 to $200 and for disk drives, from $25,000 to $100,000.

The main advantage of the optical disk or the optical data disk (ODD) as it is now being called, is the extremely large storage capacity available per disk. Most optical disks are rated in terms of gigabytes (GBytes) or billions of bytes rather than megabytes or millions of bytes. Figure 5.3 below provides some data on four optical disk systems evaluated during the course of the project.

Figure 5.3 Capacity of Optical Disk Media.

Vendor	Disk Size	Capacity per Disk	Images per Disk (300 dpi/bimodal)
Sony	8"	460 MB	4,373
Thomson-CSF	12" (2 sided)	2 GB	19,014
Storage Technology	14"	4 GB	38,027
Eastman Kodak	12"	5.7 GB	54,189

The disk capacities mentioned above represent user available capacity; all the optical disks have additional capacity which is reserved for system use.

(1) Recording Methods. Figure 5.4a shows the three types of recording methods now being used for optical data disks; Figure 5.4b shows the physical structure of a typical optical disk. Each method operates on the same principle of changing the reflectance of a portion of a disk's laser sensitive layer to distinguish between bits stored as 0 or 1. The three methods are as follows:

- Pit formation. In this method, a diode laser burns a pit in the laser sensitive layer of an optical disk. The same laser, operated at a lower power setting, "reads" the presence or absence of pits and converts the information into binary code. This approach provides high recording density but also may result in errors over time caused by separation of the disk layers and misinterpretation of debris resulting from pit formation.

- Bubble formation. This process is similar in nature to the pit formation method, except that a bubble is created in the laser sensitive layer rather than a pit. The changes in reflectivity of the bubbles are converted to binary code. This approach is more susceptible to heat than the other approaches, which could cause the bubbles to collapse.

- Amorphous/crystalline. In this method, the laser sensitive layer is altered from an amorphous (non-reflective) to a crystalline (reflective) state. No pits or bubbles are made to the disk; the reflectance at the crystalline locations is merely increased. This approach may best resist degradation and errors, and offers the best opportunity for development of a truly erasable optical disk.

Figure 5.4a

OPTICAL DISK RECORDING METHOD

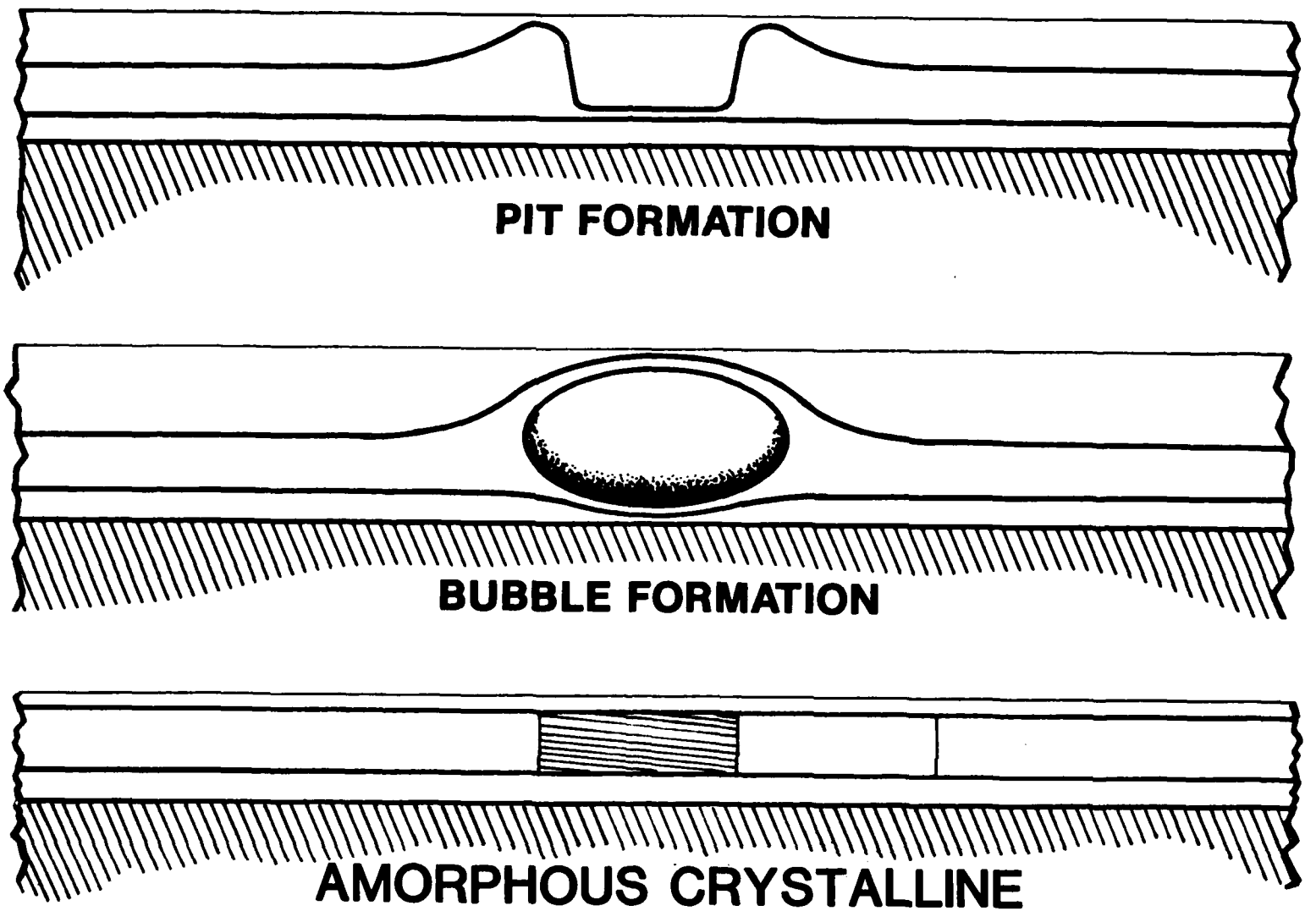
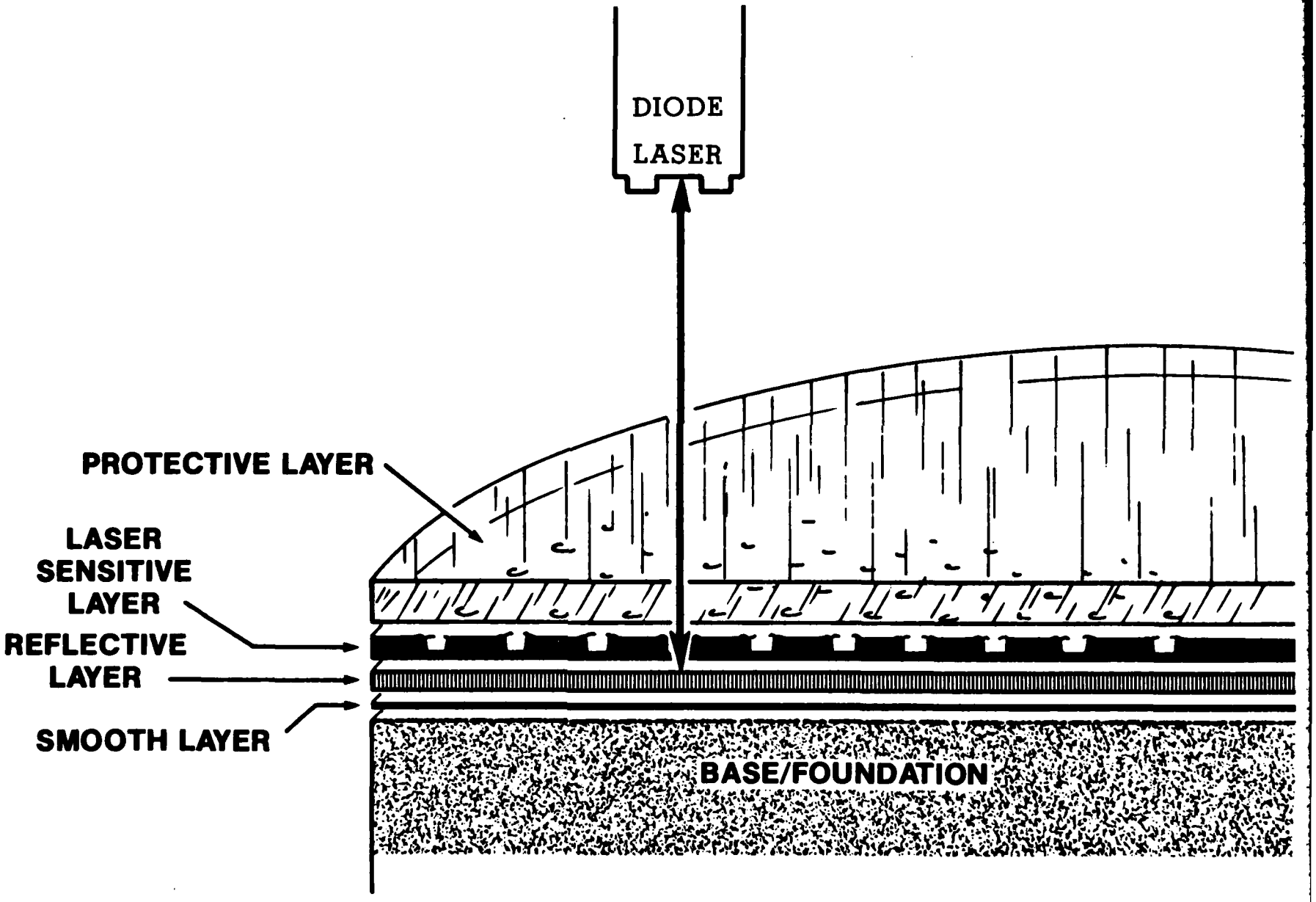


Figure 5.4b

OPTICAL DATA DISK CONSTRUCTION



(2) Error Detection. All optical disk systems available in the marketplace today are based upon the "direct read after write (DRAW)" technology where the data is read immediately after recording to verify its accuracy. If there are errors detected, the data is re-recorded in the next available space on the disk and again verified. This method insures that the image information stored on the disk is accurate, but may waste up to 30% of the disk capacity for poorly designed and manufactured disk systems.

(3) Erasability. None of the current products available on the marketplace are erasable. It is expected that erasable systems will be available within the next few years. For the Army personnel record application, however, it is recommended that an erasable media not be used in order to prevent the accidental erasure or loss of the image. Erasable optical disks may be appropriate in the future for erasing and modifying data rather than images.

(4) Degradation. Over time, optical disks, like magnetic disks, will degrade and the number of recording errors will increase. Current standards for the data processing industry do not allow error rates to exceed 1×10^{-12} (or 1 error in every trillion bits). This level of accuracy is extremely important in storing data, since the value of a number can be altered dramatically by merely changing one bit. When storing images, however, an error rate of 1×10^{-6} (or 1 error in every million bits) may be acceptable. With images, bit errors will generally result in creation of stray pixels which generally will not affect the quality of the image. In order to enable optical disks to also be used for data storage as well as image storage, the optical disk vendors will initially offer disks which meet the error rate standards for magnetic media, a standard substantially higher than that required for images.

(5) Longevity. Most vendors state that they expect that optical disks will experience a 10-year life. But since no vendor has ten years of experience with their optical disks, these results can only be surmised from accelerated aging tests (which don't adequately reflect the gradual aging process). Additionally, since the optical disks will have an error rate standard much higher than that needed for images, it is expected that images will be fully readable even after the optical disk degrades substantially. If at any time there is concern regarding degradation of the disk which might affect the images, images can be electronically transferred to a clean optical disk as often as necessary. In reality, it is expected that good quality optical disks may retain images for periods much longer than ten years.

(6) Speed. Information can be written and read from optical disks at extremely high rates of speed. For example, a 50-page record can be read from a single optical disk in less than one second; an entire disk containing 20,000 pages can be copied to another disk in approximately 20 minutes. Retrieval from a properly designed optical disk system, therefore, will appear instantaneous to the user.

(7) Durability. The optical disk is generally designed to be rigid with a glass or plastic protective layer to seal the disk recording layer from dust and atmosphere.

(8) Juke box capability. Due to the durability of the optical disk design, the disk may be used in a juke box configuration to create massive image storage capacity. In the juke box, the disk can be moved from a storage area to the disk drive in approximately 5 seconds, using a robotics device. Some vendors are discussing designs for a juke box which could include several hundred optical disks and multiple read/write units. Integrated Automation has designed a juke box for use by the Library of Congress which contains 100 Thomson-CSF optical disks and a single read/write unit; the juke box will initially have a storage capacity of 100 G-Byte, expanding to 200 G-Byte in 1984 when a two-sided Thomson disk is available.

(9) Assessment. Figure 5.5 compares optical disks with other types of storage media. Optical disk offers several significant advantages over other media:

- High storage capacity (potentially exceeding 50,000 images per disk)
- Automatic verification of accuracy using the DRAW approach
- Low cost -- $100-$200 per disk, expected to reduce to $40-$75 per disk in two years
- High speed random access of information in milliseconds
- Long life -- currently estimated at ten years
- Durable media
- Potential for use in massive storage devices (juke boxes)

There are several problems with optical disk before the media becomes widely accepted:

- The ability to mass produce the disks has not been fully proven
- The longevity and stability of the media has not yet been proven
- The reliability of the juke box concept has not been proven
- No standards for compatibility or operation have been developed
- Software for operating the optical disk system has not yet been demonstrated

(10) Conclusion. The optical disk technology is sufficiently advanced for consideration by the Army in developing its digital image system.

5.2.3 Image Transmission

Once the image has been scanned, indexed, enhanced, and stored, the image can then be transmitted to the users to perform their daily activities. Due to the large volume of digital information (or bits) required for an image, the transmission speed is extremely important for the effective operation of the system. Transmission rates of five to ten seconds per image would be acceptable in situations where only the specific images are required; but transmission rates of five to ten minutes for an entire personnel record would be considered unacceptable.

(a) Transmission Networks. There are three types of image transmission networks which must be considered in developing an effective digital image system: Image processing network, local area network (LAN), and remote area networks.

Figure 5.5 Comparison of Optical Disk with Other Storage Media

	Optical Disk	Magnetic Disk	Magnetic Tape	Microfilm	File Cabinet
1. Media Requirement: 4 GBytes	(1) Disk	(1.5) IBM 8380 Units	(40) 6250 bpi Tapes	(388) 98-Frame Microfiche (16) 2400-Frame Roll Film	(4) 4-Drawer Vertical
2. Random Access	Yes	Yes	No	Yes/No	No
3. Erasable/Reusable	No	Yes	Yes	No	Yes
4. Removable	Yes	No	Yes	Yes	No
5. Durable/Long Life	Yes	No	No	Yes	Yes
6. Error Detection and Recovery During Recording	Yes	Yes	Yes	No	No
7. Multiple Access	Yes	Yes	No	No - but duplicates can be made	No
8. Retrieval Time	Milliseconds	Microseconds	Seconds	Seconds/Minutes	Seconds/ Minutes
9. Transfer Time to Remote Location	Seconds	Seconds	Hours/Days	Days	Days

(1) Image Processing Network. Image processing network consists of the cables, channels, and equipment utilized to capture, process, and store the image. Within this network, digital information must be transmitted at extremely high rates in order to facilitate the operation of the system. Since the image transmission rate will be limited by the transmission rates of the equipment involved within the system, equipment should be selected which permits extremely high image transmission speeds between components.

Information can also effectively be compressed and decompressed at the various components as required to also facilitate transmission. For example, while scanners may produce a bit stream at a rate of 20 megahertz (20 million bits per second), most computer systems will only have input channels capable of receiving approximately 2 megahertz; therefore, the scanner equipment will match in speed provided that a compression ratio of 10 to 1 can be achieved. Some computers, however, such as Perkin Elmer can accept extremely high input rates (20 to 40 megahertz), permitting extremely high scanning speeds.

(2) Local Area Network (LAN). The "local area network" or LAN consists of the image transmission system within a small area such as within one building or between two buildings (e.g. Hoffman I and II). It is expected that the transmission rate of the LAN will be less than the image processing network, but should be as fast as reasonably possible to permit rapid exchange of information. Information handled by the remote area network will normally have to be processed first through the LAN.

(3) Remote Area Network. The remote area network handles communications between remote locations or remote local area networks. The Defense Data Network (DDN) is currently being developed to function as the remote area network for the entire military to incorporate various methods of data transmission.

(b) Transmission Media. There are basically five types of transmission media currently being used: three types of transmission media permit on-line electronic communication while two are essentially batch, off-line transmission methods. The batch method requires preparation of the optical disk and packaging.

(1) Twisted Pairs. Twisted pairs consist of copper wires, such as telephone wires, for data transmission. Project 80X is currently planning to use the existing telephone wiring system for MILPERCEN's local area network in Alexandria.

(2) Coaxial Cable. Coaxial cable consists of cable with special shielding to prevent outside interference and data errors. Narrow band systems such as Ethernet (by Xerox Corporation) is designed primarily for slower-speed data communication. Wide band systems such as Wangnet (by Wang Laboratories) can handle simultaneously a variety of high speed data transmission rates, and video and voice transmission.

(3) Fiber Optics. Fiber optics consists of glass fibers through which laser generated light is transmitted. This communication medium permits very high capacity and high speed transmission rates while occupying very little space. Many telephone cables are currently being replaced by fiber optics due to the current advantages in cost, capacity, and space.

(4) Air Freight. While air freight and mail represent batch processing for images, the effective transmission rates using optical disk is extremely attractive compared to the cost of the other on-line image transmission media. The cost example presented below assumes a two G-Byte optical disk being sent on a 3 hour flight between MILPERCEN and RCPAC.

(5) Overnight Mail. Overnight mail is another attractive batch alternative since this includes pickup and delivery of the image information. The time example presented below assumes a two G-Byte optical disk delivered within 24 hours of mailing. In reality, the delivery time will generally be less than 24 hours and may constitute only 3 prime business hours (pickup at 4:00 PM and delivery at 10:00 AM the next day).

(c) Transmission Rates. Figure 5.6 compares typical transmission rates for the transmission media discussed above. Clearly, the transmission rate for the twisted pair would be totally unacceptable for an image processing system. However, the Army currently has plans for development of a local area network at MILPERCEN and defense data network worldwide with a maximum transmission speed of 56,000 bits per second which corresponds to the fastest speed for twisted pairs. This slow transmission rate will severely hamper the image processing system and will necessitate the wide use of air freight and overnight mail for bulk image transmission and the use of COM-generated microfiche for many user requests within the local area network.

Figure 5.6 Comparison of Image Transmission Rates.

	Rate (bits/sec.)	Single Image* (sec.)	50-page Record (sec.)
Twisted Pair (DDN and MILPERCEN LAN)	56,000	15.03	751.0
Coaxial Cable			
Narrow Band	1 million	0.84	42.0
Wide Band	10 million	0.08	4.0
Fiber Optics	50 million	0.02	0.9
Air Freight	1.5 million	0.56	28.0
Overnight Mail	185,000	4.55	227.0

*8½ x 11 inch page at 300 dots/inch resolution and 10:1 compression.

(d) Conclusion. The Army is currently planning data transmission networks for both the MILPERCEN local area network and Defense Data Network to operate at maximum rates of 56,000 bits per second. Although this maximum rate may be desirable for data, the transmission rate is totally inadequate to support the image processing system. Alternative methods of transmission for on-line image processing, such as the use of fiber optics or satellite transmission, should be considered in future plans.

5.2.4 Image Presentation

There are three potential output modes for digitally recorded information: paper printers, computer output microfilm (COM), and graphic terminals. It is anticipated that all three types of output devices will find some measure of use. Terminals would find their greatest use in the Career Branch offices and with Boards, raster COM devices could be used to output records to accompany Career Management officers in their field visitation and initially for Boards (until the price of terminals is reduced), and paper printers could be used to fulfill special requests by the public. Systems designers must match the method of image presentation to user needs.

(1) Paper Printers. If paper prints are desired, the digital information may be routed to pen plotters (which use pen and ink to recreate the image on paper), electrostatic plotters, and printers such as the Xerox 9700 models (which electronically recreate the image and print it out at high speeds on paper). Paper output may be desirable for some requests. With selective paper output, only those pages desired need to be printed on paper. At RCPAC, for example, a "clean" DD214 could be printed at the touch of a button. Laser printers can be expensive, so the need must be well established.

(2) Computer Output Microfilm (COM) Devices Modified for Raster Input and Output. Most current COM devices handle alphanumeric characters, and must be modified to handle digitized (or raster) images. Among those vendors who manufacture raster COM devices are III, Dicomed, and NCR. A modified NCR device was used by the Navy in its MITS experiment in Falls Church, Virginia during 1982-83. The use of modified COM devices for digital output has the following advantages:

- Output would be similar to, but better quality than, the microfiche currently utilized by Boards. Board members would review microfiche, just as they do now. However, the microfiche generated on a COM recorder from digital information would be free of blacked-out images, out of sequence documents, and record errors.

- With high resolution terminals costing from $10,000 to $30,000, it is not cost effective to have hundreds of terminals on-line to the digitized OMPF. Having a raster COM device on-line, however, may prove to be extremely cost-effective.

One potential disadvantage that is apparent at this time, is the output speed of most raster COM devices. The modified NCR COM unit produces output at a rate of 4 megabits per second, requiring approximately 2.1 seconds per page at 300 dots per inch (1 second per page at 200 dots per inch). A 50-page OMPF P-fiche would require 1.75 minutes to generate one full record on microfiche at 300 dots per inch (.94 minutes at 200 dots per inch). Clearly that is unacceptably slow. Desirable output speeds would be 15 megabits per second, allowing for an individual 50-page record to be printed in less than 30 seconds. Unless output speed can be increased by a factor of approximately 3-5 times, the use of a raster COM device may be of limited value for large volume output.

(3) High Resolution Graphics Terminal. High resolution graphics terminals provide access to vast quantities of data without resorting to paper or microfiche. The primary factor limiting the use of high resolution

graphics terminals is their cost. Depending upon the manufacturer and quantities ordered, high resolution graphics terminals may range in cost from $7,500 to over $30,000 each. It is anticipated that the cost of these units will drop over time, paralleling the cost decline of other data processing components. When it becomes feasible to consider large numbers of high resolution graphics terminals, these are the desirable features that should be included in any unit selected:

- Full page display
- Adequate resolution, generally one-half the scanning resolution
- Rapid refresh rate for a flicker-free image
- Adjustable contrast and brightness controls
- Built-in memory to buffer additional pages for presentation
- Zoom capability
- Image rotation capability
- Ability for conference viewing
- Local paper printing capability

Clearly, it would be most desirable to place high resolution graphic terminals on the desk of each individual needing access to the OMPF.

5.2.5 Computer System Capabilities

The computer system must be extremely sophisticated in order to handle the demands of the digital image technology system. The main hardware requirements include fast input/output speeds (2 megahertz minimum and 20 megahertz or faster desirable), high capacity memory, and substantial magnetic disk storage capacity (over 500 megabytes). The other software requirements will be developed by the systems integrator to meet the needs of the Army's personnel system. Some software requirements are discussed below.

(a) Image Capture. The image capture capability includes the programming necessary to capture, manage, and manipulate the image to convert the paper document into a retrievable image on the optical disk. Some of the capabilities will include the following:

- Scanning control, including movement of the image to the daily scanning disk.
- Indexing on magnetic disk for each image.
- Quality control and image enhancement as necessary.
- Transfer of approved image to optical disk in terminal digit order.

(b) Communications. The computer system must manage on-line as well as batch requests for information.

(1) On-line Requests. On-line requests must be given immediate priority since the user is waiting. Some of the computer's functions include the following:

- Determine the location of the record image from the index.
- Load the appropriate disk on the juke box reader.
- Download the record images to temporary magnetic disks.
- Release the juke box for other uses.
- Transmit requested pages to the user.

(2) Batch Requests. Batch requests must be sequenced in order to reduce contention for the juke box and present requests to the juke box in the optimal order. It may be necessary to intermix several requests to enable all requests for a particular optical disk to be handled prior to selection of another optical disk. Batch processing can occur whenever the batch processing will not create contention or during second shifts. Some of the functions related to batch processing are as follows:

- Organize lists of records for Board review and other requests by terminal digit.
- Determine location of images from the index.
- Load the initial optical disk on the juke box.
- Transfer requested image information to on-line COM unit to produce microfiche records.
- Manage collator on COM unit (if such a device becomes available) or perform other tasks necessary to group batch requests appropriately.
- Load additional optical disks as necessary until the batch request has been completed.

(c) Backup. Routinely, a backup of all active records must be prepared to permit continuation of the operation in case of disaster. The system must identify which records must be backed up and route the images and data to the backup media.

(d) Transfer Discharge Records. Copies of records for discharged individuals can automatically be transferred to a designated optical disk or other media for subsequent transfer in digital form and, perhaps, also in COM-generated microfiche form to RCPAC for long-term storage.

(e) Purging. Periodically, when the optical disks are approximately 95% full, the active images must be transferred to new, clean optical disks to enable continued operation.

(f) Scheduling. The computer system will be responsible for scheduling access to the juke box for image capture, requests, purging, and other functions. The pilot project should include a complete juke box (even though a single reader and a few optical disks may be sufficient) to develop the scheduling techniques and software necessary to minimize contention.

(g) Special Functions. A large number of additional functions may be identified during the detailed systems design or the pilot project. Some potential functions which could be developed at a later date include the following:

(1) Character Recognition. Since the information is in digitized format, software algorithms could identify specific characters within the image. As such, this capability would enable the Army to isolate fields of information, transfer the data to existing data processing systems, store some of the digitized information in ASCII format (substantially more compact than image format), and potentially eliminate the need for images for several documents or parts of documents.

(2) Forms Overlay Capability. Since many preprinted forms are used by the Army, the storage of the preprinted information represents substan-

tial redundancy and requires additional storage space. The forms overlay capability would automatically extract the variable information from the pre-printed information and only store the variable information in the system with special coding identifying the type of form used. When the image is displayed, the preprinted form overlay will be merged with the variable information.

5.3 PROCEDURES

Section 1.1.3 presented the procedures generally followed in the existing OMPF microfiche system. Figure 5.7 provides a graphic picture of the following procedures recommended for the digital image system.

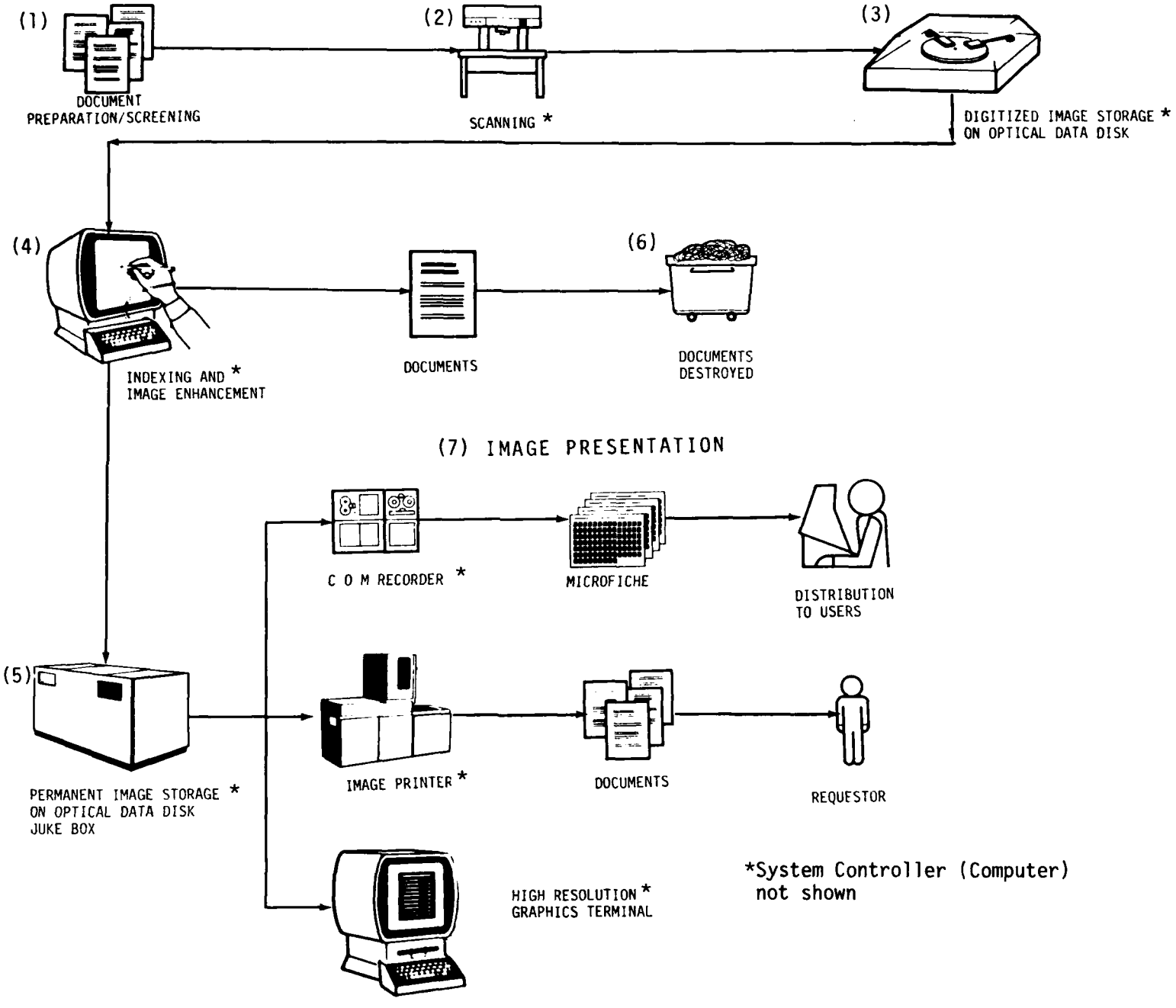
- Documents preparation and screening.
- Scanning.
- Digitized image storage on daily optical disk.
- Indexing and image enhancement.
- Permanent image storage on optical disk in juke box.
- Documents distributed or destroyed.
- Image routed to COM, laser printer, or high resolution graphics terminal.

Some of the characteristics of the proposed digital image system are as follows:

- Image Capture.
  - A desirable image capture speed would be 1800 images per hour.
  - The resolution should be 300 dots per inch, although 200 dots per inch may be acceptable provided that adequate image enhancement techniques are available for marginal images. The resolution has a major impact on storage requirements and transmission speeds. While many vendors believe that 200 dots per inch resolution is adequate, the Library of Congress has selected 300 dots per inch for its project. The Army must determine what resolution is required for adequate quality. Although this report uses 300 dots per inch in all calculations, a resolution of 200 dots per inch is preferred in order to reduce storage costs and speed transmission.
  - The document images as captured by the scanner are stored on a daily processing optical disk (although a high speed, high density tape drive might be used instead). This step is desirable for the following reasons:
    - An audit trail is maintained. As has been discussed in this report, digital image processing offers capabilities which have not existed in micrographic systems, especially image enhance-

Figure 5.7

DIGITAL SYSTEM WORKFLOW



ment. Legal issues will arise questioning the integrity of the enhanced image. Until the legality of the enhanced image is determined, it will be necessary to maintain the original image as captured at the document scan phase. Both the original scanned image and the enhanced image would be available at any legal proceedings if needed.

- The daily optical disk also stores the images during the post-processing and enhancement phase. At the current stage of development, optical disks are not erasable; therefore, the images must be acceptable after scanning or enhanced prior to their being written on the long-term storage disk. If something unforeseen occurs during the image enhancement phase and the image is altered or lost, the original scanned image can still be retrieved for a second attempt at post-processing.

- Post-scanning Processing.

  - See Section 5.4.2 for explanation of image enhancement techniques.

  - Unless care is taken in the organization of the digital OMPF, problems, such as contention for the disks in the juke box, may occur which adversely affect the system. For example, if one individual's record is stored on 50 disks over a 20 year career, it may take as long as 250 seconds to assemble that complete record. This assumes a 5 second retrieval time per image when records are stored on different disks in the juke box. More than 700 hours of system time would be required to assemble 10,000 records for a Board. Clearly, the random storage of individual images on disks in the juke box is not only undesirable, it is not acceptable.

    It is therefore recommended that all images related to an individual record be placed on the same optical disk (although the images may be stored randomly on that disk). Records should be assigned to disks by terminal digits of the Social Security Number. With all of an individual's records on a single disk, access time to the entire record is reduced to milliseconds, and the time for assembling the hypothetical 10,000 records drops to less than 3 hours. Despite the fact that optical disks are not erasable, their low-cost and high data transfer rates make it feasible to transfer data from one disk (containing active plus inactive information) to another disk (a clean disk which will now store the active information only) as the disks becomes full. Used disks can be retained as backups. This will enable the Army to maintain a record over an individual's 20 or 30 year career. Inactive information can be sent to RCPAC or elsewhere on a regular basis.

  - With the current microfiche OMPF, it is necessary to index only the M-address of the original microfiche to have access to every document in the individual's record. With a digital image system, it will be necessary to index each image after it is scanned. The following are types of data elements appropriate to index the full record into the system:

- Social Security Number	9 characters
- Name - last, first, M.I.	25 characters
- Document/file code	2 characters
- Document date	6 characters
Total	42 characters

Only 19 characters (Social Security Number, 2 letters of last name, document code, and document date) may be required to index each individual image. When microfiche records are originally converted or when new accessions are received, as few as 8 characters (document code and document date) may be required after the SSN has been keyed once.

The indexes to all documents should be stored on magnetic disk. The index can be changed as necessary to simulate purging or resequencing of documents.

5.4 SPECIAL ISSUES

Since digital image technology is only in its infancy, a number of special issues must be addressed before the Army can fully proceed in developing a comprehensive digital system. Some of these issues are discussed below.

5.4.1 Legal Issues

The legal status of digitized images, especially signatures, has never been determined in an actual court proceeding. There are statutes and ample precedent, however, which permit the introduction of microfilm, paper copies, and COM or paper prints produced from a digital computer data base. The Federal version of the "Uniform Photographic Copies of Business and Public Records Act" and the "Federal Rules of Evidence" (see Appendix C for copies of both) provide substantial legal support for the maintenance of information in digitized format provided that adequate safeguards are instituted and the court is provided with a reasonable, trustworthy, and tangible facsimile of the image.

The primary concerns related to the legality of a digitized image system can generally be met if the system exhibits "trustworthiness" in terms of the creation, maintenance, and management of the digitized image. The courts have generally viewed that a system meets this standard if the following criteria are met:

- The records were created at or near the time of the event.
- The records are maintained in the ordinary course of business.
- The records are reproduced in the regular course of business.
- The reproduction process adequately reproduces the image or forms a durable image. (Note: There is no requirement for an exact duplication of the image; rather, the reproduction must be sufficiently accurate as to enable a reasonable person to determine that the reproduction was made from the original and that there were no changes from the original.)

- The procedures used in creating the reproduction and any of the other criteria stated above can be adequately supported by evidence, if requested.

Assuming that the above criteria have been met, the original paper can be destroyed in the regular course of business and the reproduction used for all purposes including evidence.

In order to enhance the trustworthiness of the digital image system, especially until this technology receives acceptance in the judicial system, it is suggested that the following procedures be followed:

- The original, unenhanced, digitized image be maintained for long-term preservation.

- An automated audit trail must be created of any enhancements or changes made to the image, including the time of enhancement or change, operator, and algorithm utilized. This function is performed automatically by the computer system, without human intervention.

- An automated audit trail must be created for the movement of the digitized image throughout the system, including original storage on the optical disk, transfer of image to other optical disks after purging, and transfer of image to output media for presentation to any judicial or administrative proceeding. This function is performed automatically by the computer system, without human intervention.

These requirements are in addition to the normal requirements for maintaining the procedures manual, training staff, developing error detection systems, preparing periodic backup to the system, and providing periodic audits of the system. When the technology receives greater wide-spread acceptance, some of the stringent requirements stated above may be relaxed.

5.4.2 Image Enhancement

The digital image technology differs from microfilm in that techniques can be used to enhance or improve the image. These enhancement techniques may be applied to the entire image or to certain portions of the image to provide greater clarity.

The image enhancement operator will be responsible for determining which image enhancement algorithms should be applied based upon personal judgment and experience. It is expected that after a period of time and monitoring, a certain number of algorithms (approximately 10) and threshold levels will be established as "standards." The image enhancement operator will then use a limited number of algorithms, unless a particularly difficult problem is encountered.

It is expected that very little post-processing or image enhancement will be required for good quality documents (75% of all documents), and substantial enhancement required for photographics and for older, poor quality documents (25% of all documents). Vendors are now developing algorithms which hopefully

will be available to the Army by the 1985-86 time frame. Some techniques for image enhancement are discussed below.

(a) Thresholding. The scanner can detect wide variations in the level of gray scale. A threshold must normally be established to determine which levels of gray would be considered black and which white. By changing the threshold, it is sometimes possible to improve the image quality by making letters "thinner" or "thicker," as needed.

(b) Edge Enhancement. Algorithms can be applied to determine where straight lines exist and produce sharp edges by removing stray pixels from the lines.

(c) Remove Extraneous Specks. The system can examine the area immediately surrounding each pixel to determine if the pixel is actually an isolated speck.

(d) Clear Background. The threshold can be modified to produce a clear background, even with a colored original. This is particularly important due to the high D-min of the A.B. Dick original film.

(e) Darken Image. The system can convert grayish images to dense black through the thresholding process. This is particularly important when a poor quality image is encountered, especially when the image was originally a copier or reader-printer reproduction.

(f) Fill In Characters. In some instances, broken lines or "holes" in characters can be filled to enhance readability.

(g) Changing Gray Scale to Bi-Tonal (Bi-Modal). In order to facilitate the use of image enhancement and provide the image enhancement operator greater flexibility, it has been recommended that all images be scanned using at least eight levels of gray scale (3 bits per pixel). In order to reduce storage requirements, it will be necessary after enhancement to convert the digital representation from 3 bits per pixel to 1 bit per pixel (bimodal -- 0 or 1).

When good quality text is encountered, the gray scale can simply be eliminated by establishing the appropriate threshold, and applying other enhancement techniques such as edge enhancement. However, some images such as signatures, pencil marks, and especially photographs, require some level of gray scale in order to produce an acceptable, readable image.

The most promising method to emulate gray scale in a bi-modal format is through the use of screening techniques, such as those used to reproduce a photograph in newspapers. Traditional newspaper screening methods consist of a series of different sized dots in predetermined positions in a grid; smaller dots or no dots at all are used to indicate light or white areas, while larger dots are used to indicate grayer or black areas.

Since a high resolution graphics terminal produces fixed size rectangular pixels, a somewhat different technique must be utilized. Instead, small areas of the image, 2 X 2, 3 X 3, or 4 X 4 pixels, are analyzed to determine the average level of gray scale. Once the average gray scale level has been

determined, the appropriate number of pixels are "filled in" in the area under consideration to approximate the gray scale level. For example, if a 3 X 3 pixel area is under consideration and the average gray scale for all pixels in that area is 55% black, then five pixels out of the nine in the area will be filled in to produce the equivalent of gray scale. See Figure 5.8.

The requirements for gray scale and subsequent conversion of gray scale to bitonal mode can best be determined through experimentation prior to system development. Since the image quality of a marginally acceptable newspaper image after screening is 80 dots per inch, it is expected that the screening emulation in a digital image system should be approximately 100-130 dots per inch. For example, at 300 dots per inch resolution, each area of 3 X 3 pixels must be screened to produce a screening quality of 100 dots per inch or ten levels of gray scale. Several observers have indicated that at least eight levels of gray scale may be necessary for photographs.

5.5 SYSTEM COST

The Army should consider the conversion to a digital image system as early as 1987. The cost of a digital image system for personnel records in 1987, however, is difficult to project at this time. While all components of the technology are currently available, many still exist as prototypes, hand-manufactured items, or low production items. It is expected that with the growth of this industry and the expanded use of the technology, equipment costs may be significantly reduced due to larger scale production. Typical system costs have therefore been presented in this section in terms of current 1984 costs and projected 1987 costs based upon vendor estimates. Section 5.7 below, "Implementation Plan," includes estimated costs for the pilot project. Appendix D contains many of the assumptions used in preparing these cost estimates.

Costs can generally be divided into two major categories: One-Time costs (equipment and conversion costs) and operations costs. Each must be considered in preparing appropriate budgets and planning the conversion to the new system.

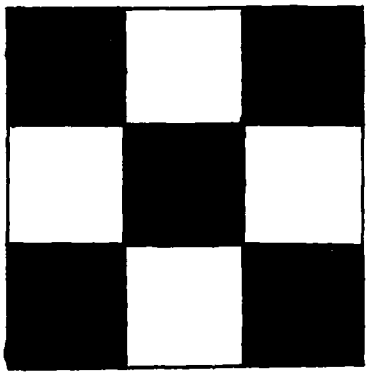
5.5.1 One-Time Costs

The existing updatable microfiche system will serve as the basis for conversion to the digital image technology system. Specially designed microfiche scanners (with filters provided to prevent damage to the A.B. Dick original film) will be utilized to convert the existing microfiche into digital image format. Document scanners will be utilized to scan all new incoming documents for both converted as well as unconverted records.

Due to the time required for conversion, it is expected that the digital image system will run parallel with the micrographics system for approximately one year at each site. Parallel operation will be required to debug the digital image system and establish effective procedures; at the same time, the microfilm system must still provide information to Boards and other users until the digital image system has been substantially converted. Whenever documents are received for updating, the original microfiche will be converted along with the update to the digital image system, and the digital image system will be utilized exclusively for all subsequent purposes. As time permits, additional

Figure 5.8 Screening Techniques for Storage of Grey Scale in Bimodal Format

Area Examined (pixels)	Resolution of Screening (dots/inch) Image Scanned at 200 dots/inch with Gray Scale	Image Scanned at 300 dots/inch with Gray Scale	Levels of Gray Scale
1 X 1 = 1	200	300	1
2 X 2 = 4	100	150	5
3 X 3 = 9	67	100	10
4 X 4 = 16	50	75	17



Levels of Gray Scale: 10

Bits per Pixel: 1

Example: 55% Screen in 3 X 3 Pixel Area (enlarged)

microfiche records can be converted to the digital system. It is therefore critical that the computer system utilized during the conversion be able to identify quickly whether requests for records will be handled through the microfiche system or the digital image system. During the conversion, however, no filming updates will be made to the microfiche; the microfiche system will be used solely for retrieval of information not yet in the digital image system.

Figure 5.9 presents cost estimates for one-time equipment costs and system conversion in the 1987 budgetary year. Actual conversion costs will depend upon the year during which funds are received and the level of conversion contemplated or provided for in the funding. Some operational funds otherwise required for management of the microfiche system can be transferred to the conversion and operation of the digital image system, except for funding designated for retrieval, duplication, and refiling of the microfiche for records not yet converted to the new system. All other functions can then be handled under the digital image system. Other staff functions not currently involved in the creation or management of the microfiche system (such as screening, accessions, separations, etc.) will not be affected by the digital image system; some requests for records can be handled much faster. Much of the equipment allocated to the conversion costs, especially equipment, facilities modification, and software, represent costs which would otherwise be required for an operational system. For simplicity, these costs have been allocated to one-time costs rather than operations.

5.5.2 Operations Costs

Figure 5.10 presents the operations costs, consisting of those costs allocated to the update of a record that has been converted. As stated above, whenever a document is received, the original microfiche record will immediately be converted to the digital image system and the update added as the next entry. Otherwise, if the record has already been converted, new images are merely scanned, enhanced, indexed, and stored.

5.5.3 Explanation of Cost Categories

The cost figures are divided into one-time and annual costs as follows:

One-time Costs

- Equipment (for conversion and operations)
- Facilities modification (for conversion and operations)
- Software/systems integration (for conversion and operations)
- Personnel (for conversion only)
- Supplies (for conversion only)

Annual Operating Costs

- Personnel (for operations only)
- Software maintenance (after first year)
- Equipment maintenance (after first year)
- Supplies (for operations only)

Figure 5.10 Estimated Operations Cost for All Installations for 1987 - Conversion Proceeding in Parallel.

	1987 Cost	MILPERCEN Number	MILPERCEN TOTAL	EREC Number	EREC TOTAL	RCPAC Number	RCPAC TOTAL	NATIONAL GUARD Number	NATIONAL GUARD TOTAL	ALL SITES Number	ALL SITES TOTAL
a. Equipment											
1. Scanners (300 dpi)											
Document	50000	0	0	0	0	0	0	0	0	0	0
Microfiche	50000	0	0	0	0	0	0	0	0	0	0
2. Computer	300000	0	0	0	0	0	0	0	0	0	0
3. Optical Disk											
Juke Box	100000	0	0	0	0	0	0	0	0	0	0
Read/Write Unit	20000	0	0	0	0	0	0	0	0	0	0
4. Graphic Terminals	6000	0	0	0	0	0	0	0	0	0	0
5. COM Unit - Raster	195255	0	0	0	0	0	0	0	0	0	0
6. Printers											
High Speed	25000	0	0	0	0	0	0	0	0	0	0
Low Speed	10000	0	0	0	0	0	0	0	0	0	0
7. Workstations	1000	0	0	0	0	0	0	0	0	0	0
8. Other	15000	0	0	0	0	0	0	0	0	0	0
9. Subtotal			0		0		0		0		0
b. Facility Modifications			0		0		0		0		0
c. Software / Systems Integration			50000		100000		50000		25000		225000
d. Personnel *		(1 shift)		(2 shifts)		(2 shifts)		(1 shift)			
1. Document Prep Clerk	18896	3	56687	19	359018	13	245644	2	37791	37	699140
2. Scanner Operator	22675	1	22675	3	68024	2	45350	1	22675	7	158724
3. Data Entry Operator	22675	4	90699	25	566870	8	181399	2	45350	39	884318
4. Image Enhancement	27714	2	55427	6	166282	3	83141	1	27714	12	332564
5. Systems Operator	31493	2	62986	4	125971	3	94478	1	31493	10	314928
6. Systems Programmer	37791	1	37791	1	37791	1	37791	1	37791	4	151165
7. Supervisor	31493	1	31493	6	188957	3	94478	1	31493	11	346421
8. Manager	50388	1	50388	1	50388	1	50388	1	50388	4	201554
9. Subtotal			408147		1563303		832670		284695		3088814
e. Maintenance											
Equipment	0.10		230053		567353		331227		146977		1275610
Software	0.20		50000		100000		60000		20000		230000
			280053		667353		391227		166977		1505610
f. Supplies											
1. Optical Disk	50	400	20000	2050	102500	1150	57500	250	12500	3850	192500
2. COM Microfiche	0.40	250000	100000	250000	100000	100000	40000	50000	20000	650000	260000
3. Printer Paper	--	--	10000	--	60000	--	30000	--	5000	--	105000
4. Overnight Mail	--	--	0	--	0	--	0	--	0	--	0
5. Other	--	--	13000	--	26250	--	12750	--	3750	--	55750
6. Subtotal			143000		288750		140250		41250		613250
g. TOTAL COST			881200		2619406		1414147		517922		5432674

* Note: Personnel budget for RCPAC does not include cost to convert paper MPRJ.

Figure 5.9 Estimated One-Time Cost for All Installations for 1987 - Conversion Completed in One Year.

		1987 Cost	MILPERCEN Number	MILPERCEN TOTAL	EREC Number	EREC TOTAL	RCPAC Number	RCPAC TOTAL	NATIONAL GUARD Number	NATIONAL GUARD TOTAL	ALL SITES Number	ALL SITES TOTAL
a.	Equipment											
	1. Scanners (300 dpi)											
	Document	50000	2	100000	3	150000	2	100000	2	100000	9	450000
	Microfiche	50000	2	100000	12	600000	6	300000	2	100000	22	1100000
	2. Computer	300000	1	300000	2	600000	2	600000	1	300000	6	1800000
	3. Optical Disk											
	Juke Box	100000	3	300000	16	1600000	9	900000	2	200000	30	3000000
	Read/Write Unit	20000	2	40000	8	160000	4	80000	2	40000	16	320000
	4. Graphic Terminals	6000	32	192000	162	972000	83	498000	16	96000	293	1758000
	5. COM Unit - Raster	195255	6	1171532	6	1171532	3	585766	3	585766	18	3514596
	6. Printers											
	High Speed	25000	1	25000	3	75000	2	37500	1	12500	6	150000
	Low Speed	10000	2	20000	9	90000	5	45000	1	10000	17	165000
	7. Workstations	1000	37	37000	165	165000	91	91000	18	18000	311	311000
	8. Other	15000		15000		90000		75000		7500		187500
	9. Subtotal			2300532		5673532		3312266		1469766		12756096
b.	Facility Modifications			100000		500000		300000		100000		1000000
c.	Software / Systems Integration			250000		150000		150000		100000		650000
d.	Personnel *		(2 shifts)		(2 shifts)		(2 shifts)		(1 shift)			
	1. Document Prep Clerk	18896	2	37791	7	132270	4	66135	1	18896	14	255092
	2. Scanner Operator	22675	4	90699	20	453496	11	249423	2	45350	37	838968
	3. Data Entry Operator	22675	25	566870	153	3469247	83	1882010	12	272098	273	6190225
	4. Image Enhancement	27714	7	193996	36	997692	20	554273	3	83141	66	1829102
	5. Systems Operator	31493	2	62986	4	125971	3	94478	1	31493	10	314928
	6. Systems Programmer	37791	2	75583	2	75583	1	37791	1	37791	6	226748
	7. Supervisor	31493	3	94478	15	472392	8	251942	1	31493	27	850306
	8. Manager	50388	1	50388	1	50388	1	25194	1	25194	3	151165
	9. Subtotal			1172792		5777039		3161247		545455		10656534
e.	Maintenance											
	Equipment	0.10		0		0		0		0		0
	Software	0.20		0		0		0		0		0
				0		0		0		0		0
f.	Supplies											
	1. Optical Disk - 4 GB	50	910	45500	6000	300000	3035	151750	480	24000	10425	521250
	2. COM Microfiche	0.40	0	0	0	0	0	0	0	0	0	0
	3. Printer Paper	--	--	0	--	0	--	0	--	0	--	0
	4. Overnight Mail	--	--	0	--	0	--	0	--	0	--	0
	5. Other	--	--	4550	--	30000	--	15175	--	2400	--	52125
	6. Subtotal			50050		330000		166925		26400		573375
g.	TOTAL COST			3873374		12430571		7090438		2241621		25636005

* Note: Personnel budget for RCPAC does not include cost to convert paper MPRJ.

A brief explanation of each cost component is included below.

(a) Equipment. The following equipment will be needed for the system:

(1) Scanners. Microfiche scanners will be needed for the conversion and document scanners for operations. Scanners should operate at a rate of, at least, two seconds per image, produce a resolution of 300 dots/inch (or higher, if required), record 8 levels of gray scale (3 bits per pixel), and produce compressed output data (using run length encoding or equivalent). All calculations are based upon a resolution of 300 dots per inch.

(2) Computer. An extremely fast minicomputer such as Perkin Elmer will probably be sufficient (although two computers may be required at EREC and RCPAC). The computer should be equipped with at least 500 megabytes of magnetic disk (or more if appropriate), and input/output channel speeds of at least 2 megahertz (to permit rapid transmission of the image information). Other features include a 6250 bpi or higher capacity tape drive, multiple input/output ports, system monitor, system printer, and system software.

(3) Optical Disk. The optical disk drive configuration consists of two components. Stand-alone read/write units are required for the daily storage of the unprocessed/unenhanced scanned image and juke boxes are required for the storage and management of the image data base. It is assumed that each unit contains its own controller and is plug-to-plug compatible with the computer system, utilizing "standard" protocols. Each optical disk used in the analysis contains 4 GBytes; each juke box holds 100 optical disks. It is estimated that each juke box will be 80% full after conversion or purging of inactive records.

(4) High Resolution Graphics Terminals. Graphics terminals must be provided to staff performing data entry and image enhancement functions. Terminals used for conversion will be provided to user groups such as Boards, Career Management Branch, Personnel Action Branch, etc., after conversion is complete.

(5) Raster COM Unit. The COM unit is used to create a microfiche or unit record copy of an entire personnel record. A raster version of a COM unit is required to handle the digital bit stream in a digital image system. At least three manufacturers produce COM units with raster input capabilities; other units can apparently be transformed using custom-made circuitry. It is impossible to determine the exact time required to produce a COM microfiche record from raster input since manufacturers of current products have little experience with digital image technology. It is expected, however, that with the growth of this technology, lower cost, high speed raster COM units will be offered in the marketplace. An estimate of two minutes has been used for the production of a COM microfiche with 50 images at 24X.

(6) Printer. A high speed printer is required which will handle raster input. The printer will be used for producing prints requested by users. Additional lower speed, lower cost printers will also be used in conjunction with graphic terminals to provide immediate paper prints as required.

(7) Work Stations. Ergonomic work stations will be required for system operators. This will enable operators to achieve maximum efficiency and enable the Army to receive full value for their large expenditure in digital image technology. Work stations should enable the operator to perform all adjustments to chairs, terminals, and work surfaces to ensure optimal efficiency.

(8) Other Equipment. Provisions have been made in the budget for other minor types of equipment such as cables, connectors, anti-static floor mats, extension cords, etc. One microfiche duplicator has been included for RCPAC; microfiche duplicators were not included at the other installations since no need was determined.

(b) Facilities Modification. The existing facilities will require modification. In most cases, substantially less floor space will be required for the digital image system than the current micrographics system. Work stations, scanners, computer equipment, and other components of the system must be optimally arranged and organized to permit efficient workflow, supervision, and efficient operation. Modifications in the electrical and environmental systems (heating, air conditioning, and ventilation) will likely be required to accommodate the new technology. Cable will have to be wired to the appropriate workstations.

(c) Software/Systems Integration. It is anticipated that a systems integrator will be used to develop the system for the Army. The systems integrator will ultimately be responsible for the selection and integration of the equipment, development of software programs to meet the Army's needs, development of operations manuals, and staff training. Since the systems integrator will make profits from the acquisition of the equipment components at OEM prices and resale at retail prices, a modest budget has been included for new software development and enhancement. It is expected, however, that the systems integrator will have previous experience with these systems and only minimal modification of existing proprietary software may be required.

(d) Personnel. The personnel required to operate a digital image system must be highly educated, motivated, reliable, extensively trained, and show good judgment. This technology differs dramatically from both micrographics and traditional data processing. Many fewer people are required to operate the digital image system than are required for the microfilm system, provided that these are the "right people."

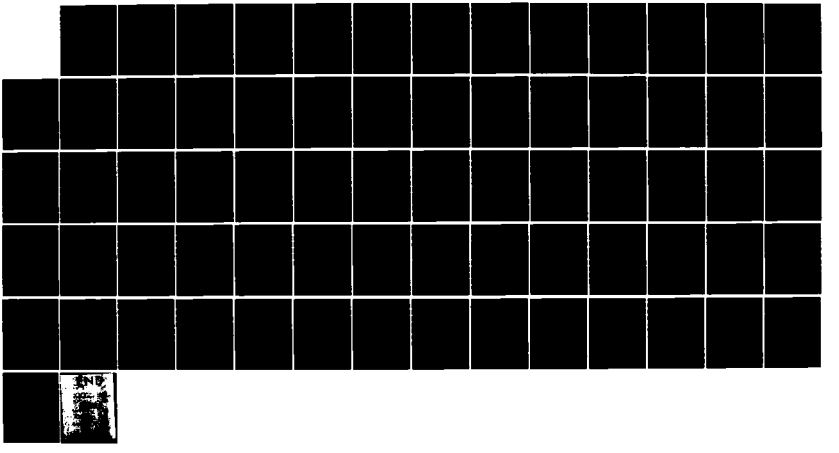
The Army and the Federal government have traditionally graded production staff extremely low, even for positions utilizing advanced technology such as updatable microfiche and computers. In order for the Army to recognize the cost savings and advantages of the digital image system, and in order to enable the system to function at all, a much different philosophy must be instituted in determining pay grades for this new technology. Some of the special qualities and responsibilities for personnel operating this new technology are discussed below.

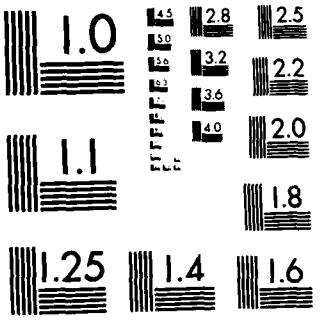
(Note: Personnel has not been included in the budgets to convert or maintain the paper MPRJ at RCPAC.)

(1) Document Preparation Clerks. Document preparation clerks are required to screen incoming documents to determine their appropriateness

AD-A144 039 OFFICIAL MILITARY PERSONNEL FILES MICROGRAPHICS SYSTEM 2/2
STUDY(U) AUSTIN ASSOCIATES ENGLEWOOD CO
R B AUSTIN ET AL. 27 JAN 84 MDA903-83-C-0490

UNCLASSIFIED F/G 14/5 NL





for inclusion in the OMPF file, remove any staples and clips, and repair any torn documents.

(2) Scanner Operators. Scanner operators are responsible for feeding documents or microfiche into the scanner, monitoring each scanned image to ensure that acceptable quality control standards have been met, identifying problems with scanner operation, and modifying controls as necessary to achieve the best quality image. This is a high production job requiring good hand-eye coordination, knowledge of scanner operations and capabilities, and substantial judgment in system operation. A conservative scanning rate of 2 seconds per image, or 30 images per minute was used.

(3) Data Entry Operators. Data entry operators are required to index each document accurately. Approximately 42 characters of information will be required to open a record and 19 characters for each update (8 for conversion and accessions). Since the image will be in an electronic form rather than in a tangible media form after scanning, the data entry operator has great responsibilities to accurately index each image; otherwise, images can readily be lost, misfiled, or rendered irretrievable. An input rate of one character per second is assumed in all calculations.

(4) Image Enhancement Specialists. No equivalent of this position currently exists anywhere in government or industry. The image enhancement specialist is responsible for reviewing each image to determine whether the image meets adequate quality standards or whether image enhancement is required. If enhancement is required, the operator will then utilize the image enhancement techniques available to improve the image and increase readability and usability. The specialist must be thoroughly familiar with the scope and ramifications of each algorithm for image enhancement, and must be able to select the appropriate variable settings to obtain an optimal image. Substantial judgment, knowledge of computers, knowledge of algorithms, and artistic ability is required to effectively perform this task. A production rate of 4 images enhanced per minute was used, with 25% of all documents requiring enhancement.

(5) Digital Image Equipment Operator. The digital image equipment operator functions to a minor extent as a traditional computer operator, but must have special knowledge and experience in the operation of the other types of equipment in the digital image system (such as scanners, raster COM units, high resolution graphics terminals, etc.). This position requires special knowledge and training since most traditional computer operators have no experience with the complexity of the components of a digital image system.

(6) Digital Image Systems Programmers/Analysts. The programs and functions of a digital image system are quite different from the traditional data processing system. Specialized algorithms are utilized for image enhancement and data compression. Image processing impacts computer capabilities much differently than data processing. Due to the relatively infant nature of this technology, people with this specialty will be difficult to locate. It may be necessary to hire the best people possible and utilize the systems integrator for training. The Army should also realize that individuals with these skills will command extremely high salaries in industry, due to the

expected growing demand for system development in this area; the Army will have to pay competitive salaries to attract good people.

(7) Supervisors. Supervisors must be knowledgeable in all aspects of the operation of a digital image system as well as traditional personnel management. Supervisors should be trained to operate each function, will be responsible for training new staff, and will participate in developing and improving the system.

(8) Manager. An executive manager will be required for the system to coordinate activities with the system integrator, develop future plans for system development, and ensure the production of a quality work product in the most efficient manner.

(e) Maintenance. Maintenance must be provided for both equipment and software to ensure their continued functioning. A small budget has been provided for software maintenance since it is expected that the in-house staff specified above will assume responsibilities for software maintenance as soon as they are capable.

(f) Supplies. A variety of different types of supplies are required for continued operation of the system.

(1) Optical Disks. A supply of new optical disks will be required for storing daily scanned images and maintaining the image data base. As stated earlier, the original scan of the image (including gray scale) will be stored on an optical disk and maintained for a long period of time. When the "daily" disk is filled (generally requiring several days or weeks), a new optical disk will be inserted in the stand-alone read/write unit. Optical disks are also required for the image data base. By storing the personnel records in terminal digit arrangement, each optical disk will be updated at approximately the same rate. Generally once per year, active information must be transferred from the disk in the juke boxes to clean optical disks, and the clean disks inserted in the juke boxes. A large supply of optical disks will be required for this purpose since it is not anticipated that erasable disks will be used in the system (nor will be desirable nor available at the time the system is developed). Additional optical disks (or magnetic tapes) may be required for transfer of records for discharged or reinstated individuals between RCPAC and the other installations.

(2) COM Microfiche. A large volume of COM microfiche will be required for distribution of information within the system. The volume of microfiche copies produced will reduce dramatically as graphic terminals are provided to user groups. It is expected that some microfiche copies will still be produced by the COM unit in the future to respond to user or field requests.

(3) Printer Paper. A supply of paper will be required for the high speed and low speed image printers.

(4) Overnight Mail. It is expected that periodically, digitized records of discharged individuals will be transferred to an optical disk and mailed overnight to RCPAC. Due to the Army's existing plans for local area networks and the Defense Data Network (with a maximum transmission rate of

56,000 bps), it is not anticipated that large quantities of images can be transmitted through communication lines between installations.

(5) Other. The budget has been provided for such other supplies as magnetic tapes, packing cartons, envelopes, clips, etc.

(g) Total Costs. Total costs have been calculated for one-time costs and annual operating costs, plus a summary projection has been provided for budgeting purposes each year by installation. Costs for variable type expenses for future years have been calculated based upon an expected 10% inflation rate and no change from the current force size.

5.5.4 Cost Justification

The issue of cost justification is extremely difficult to address at this preliminary stage. As indicated in Section 2.1 System Evaluation Criteria and Section 2.4 Problems with the Existing System, the issue of cost is not the most significant reason for changing the existing OMPF microfiche system. The issue of cost and system payback, however, should be considered.

The RAM2 project never projected a breakeven point for conversion to the current microfiche system. After projecting conversion costs of $6.6 million (for MILPERCEN and EREC), the project still projected a $2.4 million deficit after the expected eight-year life of the system. (See RAM2 Report, Figure 45, pg. 139.)

During the detailed systems design phase and the pilot project for the digital image system, the issue of cost justification and payback can better be determined. Based upon the estimated conversion and operations cost presented in Figures 5.9 and 5.10, a payback period of approximately ten years should be expected. Regardless of cost, however, the digital image system offers substantial improvements over the microfiche system and offers the potential for future enhancement and expansion, with no apparent technical limitations.

5.6 ASSESSMENT

5.6.1 Advantages

As compared to the current microfilm OMPF system, digital image technology has these advantages:

(1) Higher system speed and improved processing time.

(2) Image enhancement and error correction capabilities.

(3) Ability to delete and resequence images.

(4) There is no degradation of update capability.

(5) There is no degradation in image quality for copies made from the digitized image.

(6) The system provides for multiple access to the same record.

(7) The potential exists to extract data from digitized images.

(8) Images and data can be transmitted to remote locations.

(9) Information can be retrieved directly by terminals, rather than by duplicates.

(10) System is much less labor-intensive.

(11) Paper can be scanned immediately upon receipt.

(12) Records are never out-of-file.

(13) Records are not handled except at input and output stages.

(14) Paper is eliminated.

5.6.2 Disadvantages

The digital image technology also has some disadvantages:

(1) It is a new technology with no track record and with no operational sites at which the Army can now evaluate the capabilities of the technology. It is anticipated that many systems will be developed in the next two years.

(2) There is no standardization. Unlike current micrographic technology -- where one might be able to use Fuji film in a Bell and Howell camera, processed in a Kodak processor, and loaded into 3M cartridges for use -- digital image technology users will be dependent upon the vendors responsible for each component. There are different scanning speeds, resolutions, and means for recording images on optical disks. Until some technological breakthrough occurs or some attrition occurs in the digital image industry, there are not likely to be widely applicable standards. As inherent with all new technologies, the lack of standardization also stems from a lack of standards required by the users. Therefore, it is exceedingly important when considering the implementation of digital image technology that user requirements and specifications be explicitly defined.

(3) Data transmission speed is a limitation due to the slow speed for transmitting images currently envisioned in the Defense Data Network and local area networks.

(4) A possible disadvantage is the optical disk itself. Only one vendor in the United States is currently installing a system. Storage Technology Corporation has announced 1984 delivery dates for its new optical disk storage system. Until these systems are placed into daily use, there remains unanswered questions relative to error rates,

reliability of disks and disk drives, and system software. Current methods to artificially age optical disks cannot replicate the normal aging process.

(5) A major concern among potential users is the legality of images stored on optical disks.

Despite these potentially serious disadvantages, digital image systems utilizing optical disks for storage represent a quantum step forward in the information processing industry. Never before has the capability existed to rapidly store and retrieve so much information at such a low cost. There is widespread confidence that any current system limitations will be overcome in the next few years and that optical disk recording systems will soon take their place along side magnetic systems.

Despite the fact that there are no digital image systems currently in operation, enhancements to the current state-of-the-art are already taking place. Some vendors are working on the following: (1) increased throughput speeds while maintaining resolution, (2) color scanning capability, and (3) symbol and character recognition. In tests currently being conducted, recognition rates for characters printed by hand are exceeding 95% accuracy. Since computers are the backbone of the emerging digital image processing industry, all improvements will be contingent upon improved computer design and speed.

5.7 IMPLEMENTATION PLAN

Due to the newness of the digital image technology and the unique challenges offered by the technology, it is recommended that a pilot project be established prior to the full-scale conversion of the personnel records for the Army.

5.7.1 Pilot Project

(a) Characteristics of Pilot Site. The pilot site should have the following characteristics:

- The records group should consist of approximately 5,000 records and/or approximately 1 million images.
- The records should have a high rate of activity.
- The records must exhibit all or most characteristics found in the records at all four installations.
- The site selected must be enthusiastic about operating a pilot project, since the pilot must be operated in parallel with the existing micrographics system.
- Procedures for the existing system operation must be firmly established so that the pilot project can be managed efficiently, and effectively evaluated against the current system.

(b) Site for Pilot Project. The most likely candidate for the pilot project appears to be the personnel records for Colonels at MILPERCEN.

The Colonel records consist of approximately 5,000 records, each containing approximately 200 images. These records have a high rate of activity since Colonels are evaluated and reviewed by selection Boards several times per year. Since MILPERCEN has been operational longer than any of the other sites, the procedures have been refined and well established.

(c) Test Period. According to the timetable presented below, the design of the pilot project should begin in mid-1984 and become operational for one year during 1986. Due to the fact that this is a new and yet unproven technology, it is recommended that the Army wait at least two years before actually implementing a pilot project. During this timeframe, it is expected that other organizations, including the Library of Congress, will develop digital systems for their own use. The Army can benefit greatly from the experiences of these other organizations.

It is also expected that approximately 1½ to 2 years will be required after the decision to develop a pilot is made, to determine final user requirements, begin detailed systems design, select the systems integrator and equipment, and develop the necessary software programs. While some development may continue during the course of the pilot project, it is recommended that the entire system, including hardware, software, personnel, and procedures, be in place at the time the pilot project begins.

(d) Evaluation. It is recommended that an independent, outside evaluator be selected to evaluate the pilot project during the course of the year. This will ensure the effectiveness of the system prior to large scale conversion at the other sites. The independent evaluator should play an active role in providing recommendations for improving the system during the course of the evaluation.

(e) Pilot Project Budget. Figure 5.12 provides a cost estimate for the pilot project converted into estimates for the year the expenses will actually be incurred. Since the pilot project should reflect the operating conditions now contemplated for the operational system, the same equipment and software anticipated for the operational system has been included in the budget. Some savings can be realized during the pilot such as a reduced number of scanners, one instead of three jukeboxes, and a reduced number of terminals and other peripherals. Even though the system could probably function with a single optical disk reader, using interchangeable optical disks, a juke box is recommended to provide the Army with sufficient experience in the operation of the juke box to optimize its usage and reduce contention problems in the actual operational system. It is anticipated that all equipment used during the pilot can be used as part of the actual operational system. Some modifications in equipment and software are expected during the course of the pilot project.

5.7.2 System Development

(a) Timetable. The following timetable is suggested for the startup period for each task in developing the pilot system, converting to the new system, and operating the new system.

Figure 5.12 Estimated Budget for a Pilot Project in 1986 at MILPERCEN for 5000 Colonel Records.

		Number	1984 Costs Item	1984 Costs TOTAL	1986 Costs Item	1986 Costs TOTAL
a.	Equipment					
1.	Scanners (300 dpi)					
	Document	1	100000	100000	50000	50000
	Microfiche	1	100000	100000	50000	50000
2.	Computer	1	350000	350000	300000	300000
3.	Optical Disk					
	Juke Box	1	200000	200000	100000	100000
	Read/Write Unit	1	30000	30000	20000	20000
4.	Graphic Terminal	8	15000	120000	7500	60000
5.	Raster COM Unit	1	155000	155000	180792	180792
6.	Printers					
	High Speed	1	25000	25000	25000	25000
	Low Speed	1	10000	10000	10000	10000
7.	Workstations	11	1000	11000	1000	11000
8.	Other	1	15000	15000	15000	15000
9.	Subtotal			1116000		821792
b.	Site Modification			100000		125000
c.	Software/Systems Integration			250000		250000
d.	Personnel					
1.	Document Prep.	1	15000	15000	17496	17496
2.	Scanner Operator	1	18000	18000	20995	20995
3.	Data Entry Op.	4	18000	72000	20995	83981
4.	Image Enhance.	2	22000	44000	25661	51322
5.	System Operator	1	25000	25000	29160	29160
6.	Sys. Programmer	1	30000	30000	34992	34992
7.	Supervisor	0	25000	0	29160	0
8.	Manager	1	40000	40000	46656	46656
9.	Subtotal			244000		284602
e.	Maintenance					
	Equipment	0.10		111600		82179
	Software	0.20		50000		50000
				161600		132179
f.	Supplies					
1.	Optical Disk-4GB	180	200	36000	75	13500
2.	COM Microfiche	30000	0.30	9000	0.40	12000
3.	Printer Paper	--	--	3000	--	3499
4.	Overnight Mail	--	--	0	--	0
5.	Other	--	--	4800	--	5599
6.	Subtotal			52800		34598
g.	Evaluation			150000		175000
h.	TOTAL COST			2074400		1823171

February 1984	-	Accept Project Report
	-	Budget pilot project and system conversion
July 1984	-	Begin detailed systems design
April 1985	-	Select systems integrator
	-	Final systems design
	-	Equipment selection
	-	Programming
December 1985	-	Implement, test, and document system for pilot project
1986	-	Operate and evaluate pilot project
1987-88	-	Complete conversion at all sites
1989-90	-	Begin complete operation at all sites using new system

(b) Budgeting. Upon approval of this Project Report and the selection of a pilot site, all installations should prepare budgets for developing a digital image system at their installation. Budget phasing should basically conform to the suggested timetable. Each installation should be certain, however, that enough funds have been allocated to enable them to convert to the new system rapidly and completely, and begin operations at the designated time.

The RAM2 report and subsequent funding provided only for conversion of records at MILPERCEN and 75% of the records at EREC. No funding nor plans were provided for the conversion at RCPAC and the National Guard. Based upon the problems experienced during the previous conversion, it is recommended that a consolidated plan be developed for the conversion of all four sites according to the specified timetable. Due to the different command structures for each installation, it will probably be necessary to submit separate budgets. The master plan, however, should include provisions for all sites to work together and develop compatible systems according to the most advantageous timetable.

5.8 ACTIVITIES IN DIGITAL IMAGE TECHNOLOGY

Since digital image technology is relatively new, relatively few systems have been developed. It is expected that many more systems will be developed and operational within the next two years. At this time, there is a great deal of activity in this field, with many vendors working toward the development of new systems. Some of the significant activities in terms of both projects and products are as follows:

- Library of Congress (Washington, D.C.) The Library of Congress is developing a pilot project to prove the feasibility of using digital image technology for the management and storage of library materials. The three-year project will include conversion of materials now in both paper and micrographics form. Because the appearance of the image for archival library materials may sometimes be more important than the information, the Library of Congress is scanning at 300 dots/inch to obtain a high quality image.

- Integrated Automation (Berkeley, CA). Integrated Automation serves as the systems integrator for the Library of Congress project. They have previously developed (in France) the first known digital image system. Besides writing software and integrating equipment obtained

from other vendors, Integrated Automation has also developed its own scanner and a juke box using 100 Thompson-CSF optical disks.

- Thompson-CSF (France). Thompson-CSF developed one of the first operational optical disk systems and is now developing a marketing organization in the United States for their disk drives. The Thompson optical disk uses the "bubble" approach for storing information, using a gold-platinum media. The Thompson disk drive is compact and should sell in the range of $25,000 to $30,000.

- Drexler Technology Corporation (Mountainview, CA). Drexler was the first company to offer optical recording media on a commercial basis. The optical disk uses silver halide particles and an insulating underlayer devoid of reflective metal. Information is stored on Drexler's optical disk by a laser diode which burns holes into the medium. Drexler expects that when production of 12-inch disks reaches 100,000 annually, the cost per disk will drop to about $40.00 each.

- Storage Technology (Louisville, CO). Storage Technology Corporation is in the final development stages for a 14-inch optical disk capable of storing 4 Gigabytes of user information. The system will be field tested in Spring 1984 and should be commercially available by September 1984. The company has developed a read/write unit for single disks, and is discussing the possibility of developing a juke box.

- Systems Group of Colorado (Englewood, CO). Systems Group has developed a series of scanners for small documents up to large engineering drawings. The scanners are capable of producing a resolution from 200 to 1500 dots/inch, depending on the optics and electronics used. While an aperture card scanner is being developed, the company appears capable of developing a microfiche scanner if the demand exists.

- Sony (Japan). In October 1983, Sony demonstrated a prototype small-scale digital image system as part of its presentation to the International Patent Office. The system currently consists of a small slow-speed scanner (240 dots/inch) and a small 8-inch optical disk drive. Plans call for increasing the resolution to 300 dots/inch with a display of 150 dots/inch. The primary thrust seems to be toward small-scale workstation systems, rather than large company-wide systems.

- Wang Laboratories (Lowell, MA). In late 1983, Wang announced the availability of its PIC (Professional Image Computer) system with delivery expected in early 1984. The system is designed as an individual work station with a 10 megabyte Winchester magnetic disk, having a storage capability of 100 documents. The system is designed for those applications which require an integration of images and data or text. A small slow-speed 200 dot/inch desktop scanner is provided as part of the system. While the system appears to have limited capabilities, it represents the first "off-the-shelf" system

available in the digital image field. Optical disks will be provided when available.

- Matsushita (Japan). Matsushita has announced the availability of the first erasable optical disk and the development of a 50-disk juke box. The company is currently marketing the Panafile digital document filing system. The first erasable optical disk and disk drive is being developed.

The activities mentioned above represent only a small sampling of the total activity in the digital image field. It is expected that new products will be announced in 1984 and 1985, and new systems will be developed during this time period. The Army should keep abreast of these activities as part of its own system development process.

CHAPTER 6. COMPARISON OF SYSTEM DEVELOPMENT ALTERNATIVES

This chapter compares the three system alternatives now available to the Army:

- Continue to operate existing updatable microfiche system with enhancements.
- Convert to a micrographics-based transition technology, such as an automated document storage and retrieval system with digital image transmission (ADSTAR+DIT).
- Convert to a digital image system, after a pilot test.

The results of this chapter clearly indicate that the digital image technology alternative offers the Army the best opportunity to resolve the problems of the existing system, provide new system capabilities and opportunities for growth, and obtain a return on investment in approximately five years.

6.1 SYSTEM EVALUATION CRITERIA

Section 2.1 reviewed the system evaluation criteria and the scoring method used for this project. Figure 6.1 expands the system evaluation analysis to include a comparison of the three major alternative approaches discussed in this report. As the "Total Adjusted Scores" clearly indicates, both the ADSTAR+DIT and the digital image technology scored significantly higher than the current system. The score for the digital image technology was in fact higher than the other two systems under consideration.

The "Weighted Scores" are provided to enable the reader to compare the weighted scores for individual criteria, as well as group criteria. The most significant difference between the systems was apparent in the "Image Quality" criteria. While the current system has severe problems related to image quality, resequencing of images, and removal of images, the other two alternatives reviewed provide substantial improvement. The digital image system responds effectively to all Image Quality criteria and scores heavily due to its image enhancement capabilities. The alternative technologies achieved the highest ranking scores for a group criteria as follows:

- Digital image technology
  - Image Quality
  - Security (tie)
  - Image Creation/Management
  - Systems Development
  - Dissemination/Use
  - Personnel
  - Cost
  - Environment
- ADSTAR+DIT
  - Security (tie)
  - Integrity

Figure 6.1 Comparison of Alternative Technologies.

System Selection Criteria	Weighted Scores			Total Adjusted Scores		
	Current System	ADSTAR+ DIT	Digital Image	Current System	ADSTAR+ DIT	Digital Image
Image Quality						
a. Readable image	14.01	14.01	14.01			
b. Ability to delete error/image	6.25	25.00	25.00			
c. Ability to resequence images	7.01	23.35	23.35			
d. Ability to enhance poor images	7.50	7.50	25.00			
e. Acceptable reproduction of photo	6.00	4.00	16.00			
ADJUSTED TOTAL				32.61	59.09	82.69
Security						
a. Backup for data and images	18.68	18.68	18.68			
b. Restricted access to information	10.51	23.35	23.35			
ADJUSTED TOTAL				58.40	84.10	84.10
Integrity						
a. Ability to retain image 75 years	6.68	20.00	16.00			
b. Safeguards to prevent lost info.	10.83	21.65	17.32			
ADJUSTED TOTAL				31.24	74.32	59.46
Reliability/Maintenance						
a. Reliability of system	15.32	13.80	13.80			
b. Responsive vendor support and maintenance	16.00	16.00	12.00			
ADJUSTED TOTAL				57.70	54.90	47.53

System Selection Criteria	Weighted Scores: Current System	Weighted Scores: ADSTAR+ DIT	Weighted Scores: Digital Image	Total Adjusted Scores: Current System	Total Adjusted Scores: ADSTAR+ DIT	Total Adjusted Scores: Digital Image
Image Creation/Management						
a. Rapid image capture	8.55	11.01	18.35			
b. Rapid information retrieval	8.60	12.90	21.50			
c. Ease of updating record	14.68	12.00	16.00			
d. Ease of retrieving information	10.88	18.68	23.35			
e. Ease of indexing	11.66	7.00	10.50			
f. Ease of making backup	5.32	16.00	16.00			
g. Minimal filing/handling of record	4.60	9.20	9.20			
h. Potential to reduce human errors	13.32	16.00	16.00			
i. Minimal human intervention	9.32	16.00	20.00			
ADJUSTED TOTAL				31.67	43.28	54.98
System Development						
a. Use of proven technology	8.89	13.32	3.33			
b. Flexibility to develop new systems	9.32	12.00	20.00			
c. Minimal disruption of current system during conversion	9.18	7.34	14.68			
d. Potential for paperless office	15.89	14.68	18.35			
e. Potential for automatic extraction of data from images	10.00	4.00	16.00			
ADJUSTED TOTAL				34.09	32.85	46.31
Dissemination/Use						
a. Rapid transmission of images between sites	3.99	9.00	15.00			
b. Rapid access to images by users	8.55	11.01	18.35			
c. Ability to retrieve images while record is being updated	5.32	20.00	16.00			
ADJUSTED TOTAL				18.15	40.65	50.13

System Selection Criteria	Weighted Scores			Total Adjusted Scores		
	Current System	ADSTAR+ DIT	Digital Image	Current System	ADSTAR+ DIT	Digital Image
Personnel						
a. Minimal staff size	6.22	8.01	13.35			
b. Minimal staff training	11.09	9.99	6.66			
c. High job satisfaction	6.22	8.01	10.68			
ADJUSTED TOTAL				19.42	21.47	25.33
Cost						
a. Low system conversion cost	6.22	8.01	5.34			
b. Low system operating cost	6.06	7.80	13.00			
ADJUSTED TOTAL				13.86	17.85	20.71
Environment						
a. Minimal space requirements	6.22	9.32	11.65			
b. Minimal noise level	5.00	8.00	8.00			
c. Comfort of working environment	7.57	9.32	9.32			
ADJUSTED TOTAL				11.92	16.89	18.37
TOTAL				309.06	445.40	489.60

- Current system
    - Reliability/Maintenance

The raw data used to develop this analysis is provided in Appendix E.

6.2 PRODUCTION AND STAFF REQUIREMENTS

Figure 6.2 provides a simple comparison of production and staff requirements for the three alternatives considered. (See Appendix D for production rates.) This figure is designed to provide some quantitative comparisons for typical system operations. The results clearly indicate that from the standpoint of staff requirements and production time, the digital image system is clearly superior to the other alternatives. The personnel costs, however, may be slightly higher in some cases due to the higher salary levels required by the sophistication of this technology.

6.3 CONVERSION REQUIREMENTS

Figure 6.2 also emphasizes the fact that the existing system does not require additional conversion, saving substantial time and money. Both other systems must be converted prior to full operation. The ADSTAR+DIT approach presents some particularly difficult issues since very rare and expensive equipment is required to convert the existing microfiche into roll film format or the image must be digitized and converted to roll film. The microfiche version of ADSTAR+DIT has been rejected due to the extremely large number of units required, e.g., over 100 at MILPERCEN and almost 700 at EREC. Once the image is in digitized format, however, the conversion back into micrographics format is a step backwards; substantial additional benefit can be derived by keeping the image in digitized format.

6.4 SUBJECTIVE ANALYSIS

The various alternatives have been reviewed throughout the course of this report. The major factors which favor the development of a digital image system are as follows:

- The existing updatable microfiche system has severe weaknesses which cannot be resolved and adversely affects the operation and use of the system. (See Chapter 2)

- While the ADSTAR+DIT alternative resolves many of the problems with the existing system, conversion to roll film format from microfiche requires expensive and rare conversion equipment or a full digital image system. The ADSTAR+DIT technology also has deficiencies, especially with the time required to assemble the complete OMPF record for an individual. (See Chapter 4)

- The digital image technology responds to all problems with the existing system and offers several opportunities for improved operation. Some of the additional advantages offered by digital image technology are image enhancement, multiple access to information, rapid access to information, reduction in human intervention, and potential for extraction of data from images. The drawbacks relate to the newness of the technology and some concerns regarding image quality. (See Chapter 5)

Figure 6.2 Comparison of Alternative Approaches for the Army OMPF System.

	Existing System		ADSTAR+DIT System		Digital Image Technology	
	A.B.Dick System 200 Updatable Microfiche plus Access-M ADSTAR		Ragen 1010		Scanners, Optical Disk, Raster COM -- See Chapter 5.	
Average Staff Salary:		16000		16000		20000
	Number	Cost	Number	Cost	Number	Cost
SYSTEM OPERATION						
1. Accessions: 10000 (accession packets)						
a. Hours Required	2381		1667		1282	
*b. Staff Required	1.91	30525	1.34	21368	1.03	20546
2. Updates: 380000 (documents: 1.5 pg)						
a. Hours Required	23457		6209		5149	
*b. Staff Required	18.80	300728	4.98	79604	4.13	82517
3. Requests: 250000 (for microfiche)						
a. Hours Required	14881		37879		8013	
*b. Staff Required	11.92	190781	1.11	17806	1.11	22258
4. Separations: 10000 (Separation Packet)						
a. Hours Required	833		833		833	
*b. Staff Required	0.67	10684	0.67	10684	0.67	13355
5. TOTAL						
a. Hours Required	41552		46588		15277	
*b. Staff Required	33	532718	8	129462	7	138675
SYSTEM CONVERSION						
No. of Records 100000						
Pages/Record 75						
a. Hours Required	0		64103		49020	
*b. Staff Required	0	0	51	821828	39	785571

* Production staff only -- does not include supervisory, management, systems development, or other technical staff.

6.5 CONCLUSION

The evidence is clear that the digital image technology offers the Army the best opportunity to resolve problems of the existing system and to enhance operations for the future. During the time required to develop a pilot project and convert to the new technology, some enhancements should still be developed for the existing OMPF microfiche system to improve operations until the new system is developed.

CHAPTER 7. SPECIAL APPLICATIONS OF MICROFILM

In addition to the review and evaluation of the existing OMPF microfiche system, the contract required an examination of potential microfilm applications in the Awards Branch, the Promotions Branch, the Central Clearance Facility (Ft. Meade), and other groups of records encountered by the contractor.

7.1 AWARDS BRANCH

The Awards Branch is responsible for the administration and research of records of awards presented by the Army. Many requests are received each year for awards that were allegedly authorized at some prior date, but were never received by the requester. Requesters frequently have little or no information regarding the date or nature of the award. In a few cases, fraudulent claims have been made for awards which were never authorized nor presented.

7.1.1 Background

Approximately 500,000 General Orders (GO) were produced during the Vietnam era by various divisions or higher headquarter commands, authorizing various awards. The existing set of paper records are believed to be the only remaining copies of these General Orders for the Vietnam period. These records create great concern since they are actively used, may be deteriorating through age and use, are subject to loss or destruction, and cannot be replaced. The National Archives wants custody of these records which will hamper the Awards Branch in retrieving records and responding to requests, and will subject the records to additional security hazards through public access.

7.1.2 Findings and Problems

(a) Organization of Records. The paper records are physically arranged by issuing headquarters, and then numerically by GO number. File boxes are indexed to indicate the inclusive dates of the contents.

(b) Records Condition and Quality. These records were created under field conditions, on 8½ x 11 inch paper, and represent mimeographed copies of originals. The quality of the printed image varies from poor to good.

(c) Index. No index exists relating recipient name and social security number (military number) to individual orders.

(d) Security. Records are presently stored in a locked security room. Since the security room is in a conventional office building, the records are subject to the same fire hazards and water damage present in any office building. There is no backup to these important records; severe hardship could result if records are lost, destroyed or damaged. There is great concern regarding the security of records once they are transferred to the National Archives.

(e) Workflow. Since the records are stored some physical distance from the Awards Branch, considerable nonproductive time is experienced by staff in walking to and from the security room. If several different head-

quarters must be searched before the proper GO is located or several requests are being handled simultaneously, staff must either spend considerable time in the records room (away from their desks) or make a number of trips to the security room.

(f) Retrieval Procedures. The entire retrieval procedure is now conducted manually:

- A "best guess" of the issuing headquarters is made.
- A "best guess" of the probable date of the award is made.
- The probable box containing the General Orders is retrieved for research based on headquarters name and date on the box label.
- The documents are scanned individually, looking for the individual's name, then checking the social security number to verify the individual's identity.
- If the record is not located, the search is expanded to cover other periods of time during which the award may have been authorized.
- The search ceases and the award declared "not found" only when all possibiliites are exhausted.

Under the best of circumstances, research of these records is extremely slow and very labor intensive. The success of the search often depends on the experience and patience of the individual performing the search.

(g) Timetable. The Awards Branch requires an improved system for managing the General Orders at the earliest possible date.

7.1.3 System Alternatives

Several alternative systems were considered as part of this project.

(a) Optical Scanning. Optical scanning, and the digital storage of the images, is an emerging technology that will probably not be economically attractive for this application until the late 1980s. Once the image has been scanned, algorithms can be applied to recognized characters and automatically produce an index. After reviewing this problem with experts in the field, it was determined that the character recognition algorithms have not been adequately perfected at this time and the cost for character analysis would be prohibitive.

(b) Indexing. Each individual entry found in the General Orders can be indexed after microfilming the documents, using traditional keystroking methods. Indexing should minimally include name, social security number, type of award, date of award, General Order number, and headquarters designation. Assuming that each General Order contains five names and 75 keystrokes are required to index each individual entry, a total of 187 million keystrokes would be required to generate this index. One service bureau has estimated that the cost of data entry, without verification, would cost at least $275,000.

The cost of indexing each individual entry, however, cannot be justified based upon the value received. As a practical matter, the value of the awards file should decrease over time. First, the majority of the award authorizations will never be referenced. Second, the need for referencing this file should

constantly decrease as "contested" awards are resolved and as time takes its toll on would-be claimants.

Indexing only the GO number and date was also considered. Since the records are already in numerical and chronological order, however, there is very little need to index the location of each individual order and date. The awards can easily be scanned individually on microfilm, aided by eye-readable flashcards.

Since new General Orders and awards are being issued constantly, it may alternatively be appropriate to microfilm and index these records as they are produced, or in batches every 6 months or so. The cost for indexing new awards will be minimal, and the information will then be available while the awards are most active and can serve as a reference for the future. Alternatively, these new orders might be digitized and interpreted in the future.

(c) Microfiche. The generation of microfiche--whether produced using updatable microfiche, a jacket system, or a step and repeat camera--is labor intensive and expensive. Regardless, updatable microfiche and jacket systems are best utilized for applications requiring a unitized format, with the capability to add new images as required.

Microfiche, in any format, is subject to misfiles unless color coded, edge-notched, or stored in an automatic retrieval unit. For the Awards Branch, where many documents must be scanned to locate the desired ones, a significant amount of time would also be required to locate the microfiche, position the microfiche in the reader, and return the microfiche to the file.

(d) Roll Film in Cartridges. The most appropriate approach for the Awards Branch is the use of roll film (with blip encoding optional) and cartridges. These records represent the classic application for which roll film is the best alternative: a large document collection, documents are in a specified sequence, and the sequence is not subject to change.

Roll film offers the following advantages:

- The film is protected from handling.
- A large number of records can be quickly and easily loaded into a reader.
- Misfiles are impossible.

No additional indexing is needed with this alternative other than labels on the cartridge. Each cartridge would have a label on the end with the roll number, division name, inclusive order numbers, inclusive order dates and flash card locations. The label on the face of the cartridge should contain the location of flashcards. (Indexing for each entry could be performed at a later date from the microfilm, but this approach does not seem necessary nor practical.)

Filming can be performed either by an outside service bureau or by using existing Army capabilities. Figure 7.1 provides system requirements and cost estimates.

Figure 7.1 Awards Branch--System Requirements and Cost Estimates.

1.	Filming - Service Bureau Based on 500,000 images, including minimal document preparation		$33,000
2.	Duplicates - Service Bureau Estimate Based on 3 duplicates in cartridges with labels 3 sets @ $1,600		4,800
3.	Equipment		
	a. Reader-Printer 3M 500C or equivalent with 24X lens 2 @ $4,600	$9,200	
	b. Reader-Printer Stands 2 @ $300	600	
	c. Film Cartridge Carousel 360 cartridge capacity	400	
			10,200
4.	Supplies		
	a. Reader-Printer Paper	$ 125	
	b. Other: Labels, reader cleaner, etc.	100	
			225
5.	TOTAL		$48,225

7.2 PROMOTIONS BRANCH

7.2.1 Background

The Promotions Branch maintains the records of non-selected officers. This material must be retained in the exact sequence and format as presented to the Boards. These records are used to answer inquiries and to respond to possible litigation. These are highly confidential records and require a high degree of security since they represent the only copy. Since no statute of limitations exists on appeals, the records are presently maintained indefinitely. (A five-year statute of limitations for appeals is now being considered by Congress. Final approval cannot be expected for several years and the impact of the statute will be difficult to determine for a period after approval.)

7.2.2 Findings and Problems

(a) Volume. The record series contains approximately 420,000 documents.

(b) Record Type. The filing system contains three types of documents: computer printouts with hand notations, 8½ x 11 inch documents, and microfiche.

(c) Floor Space. The records series currently occupies considerable floor space in a secure room. The Promotions Branch is planning to move to a different location and floor space requirements are a major concern.

(d) Security. These are the only copies of these confidential records. The Army could experience substantial injury (such as loss of expensive lawsuits) if these records are lost or destroyed.

(e) Document Arrangement. Records are arranged by promotion board and date, then individually by officer. All documents must be retained in the exact order presented to the board.

7.2.3 System Alternatives

Similar to the Awards Branch, the Promotions Branch can effectively develop a roll film system in cartridges. No additional index is required other than the existing index specifying types of boards and meeting dates.

The estimated cost for developing the microfilm system is provided in Figure 7.2.

7.3 CENTRAL CLEARANCE FACILITY, FT. MEADE

The Central Clearance Facility is responsible for processing security clearances. They maintain only a relatively small volume of records that are kept for a short period of time. When the investigation is complete, these records are returned to the Defense Investigative Service or transferred to the Central Security Facility which are under different commands.

Figure 7.2 Promotions Branch--System Requirements and Cost Estimates.

1.	Filming--Service Bureau Based on 420,000 images		$30,000
2.	Duplicates--Service Bureau 1 set @ $1,360		1,360
3.	Equipment		
	(a) Reader-Printer (3M 500C or equivalent)	$4,600	
	(b) Reader-Printer Stand	300	
	(c) Film Cartridge/Microfiche Storage Cabinet with Lock	750	
			5,650
4.	Supplies Reader-Printer paper, etc.		225
5.	TOTAL		$37,235

The project staff visited this facility as required by the contract. The Project Committee agreed that the Central Clearance Facility had no need for microfilm and that the other potential applications were under a different command which put them outside the scope of this project.

7.4 OTHER APPLICATIONS OF MICROFILM

7.4.1 MILPERCEN Career Management Branches

The Career Management Branches at MILPERCEN maintain separate filing systems consisting of a copy of the most recent microfiche, the evaluation reports in paper form, and other documentation required to perform the career management function. The paper copies of the evaluation reports serve as a backup to the OMPF microfiche system and are used to reconstruct the updatable microfiche original as required. (A new original could be constructed using reader-printer copies of the correct images, but the quality would be substantially less than filming the original paper evaluation reports.) As such, there is built in redundancy between the paper files maintained by the Career Branches and the OMPF.

Since many of the documents maintained in the Career Branches files are short term documents or duplicates, working copies of OMPF materials, microfilm would not be appropriate for this file. It would be desirable in the future, however, to eliminate the paper evaluation reports and require the staffs to rely on the microfiche record or provide them access to the digital image system.

The filing systems at the Career Branches could be improved dramatically, however, if the folders were converted to full side tab with color coding for the first two letters of the officer's last name. Vinyl guides should also be used to subdivide the file.

7.4.2 RCPAC -- MPRJ or 201 Files

RCPAC has responsibility for maintaining the paper MPRJ for separated and retired individuals. These files include medical records, the MPRJ documents, and a copy of the OMPF microfiche (if one was created). Once an individual is discharged, the MPRJ are transferred to NPRC for permanent storage.

In 1973, the fire at NPRC destroyed or damaged over 17.5 million military records. Since this was the only record, substantial problems resulted and large costs were incurred to reconstruct information. The fire influenced the conversion of the OMPF file to microfiche for better protection of the records.

In reality, no backup protection exists for the paper MPRJ including the medical records (although much of the incidental information may be valueless). Another fire could be catastrophic. Additionally, valuable space at RCPAC is allocated to records storage.

The MPRJ can be effectively microfilmed at some reasonable period after discharge. The paper documents should be carefully examined to determine which records should be filmed. A high-speed, high-quality microfiche camera, such as the TDC Documate II, should be used. Medical records, including

dental records, can effectively be filmed with this system. X-rays can be cut to microfiche size and stored in the same packets or stored separately. Original microfilm could be kept at NPRC's Winnebago site, and duplicates at RCPAC for reference. The paper files can be destroyed after adequate inspection of the microfilm.

CHAPTER 8. RECOMMENDATIONS

8.1 FUTURE SYSTEM DEVELOPMENT

RECOMMENDATION 1. THE EXISTING OMPF UPDATABLE MICROFICHE SYSTEM SHOULD BE ENHANCED. WITH THE RECOMMENDED MODIFICATIONS, THE UPDATABLE MICROFICHE SYSTEM SHOULD ENABLE THE ARMY TO CONTINUE OPERATING THE OMPF SYSTEM UNTIL A DIGITAL IMAGE SYSTEM IS DEVELOPED.

Section 8.2 below recommends a variety of changes to the existing OMPF updatable microfiche system which should enhance operations. With these modifications and subsequent improvement in image quality, duplicate quality, and productivity, the Army can continue effectively operating the OMPF system for at least five more years, or until a digital image system is developed.

RECOMMENDATION 2. AN ALTERNATIVE MICROFILM-BASED SYSTEM SHOULD NOT BE DEVELOPED FOR MAINTENANCE OF THE OMPF.

Chapters 4, 5, and 6 of this report review the specific reasons why the Army should not convert to any other microfilm-based technology, including the so-called "transition technologies." The Army can best be served by enhancing the existing system and converting to a digital image system at the appropriate time.

RECOMMENDATION 3. A DIGITAL IMAGE SYSTEM SHOULD BE DEVELOPED FOR MAINTENANCE OF THE OMPF.

Chapter 5 of this report reviews the state of the art of digital image technology and assesses the potential of this technology for meeting the needs of the Army OMPF system. (Additional recommendations are provided later in this section.) In essence, the digital image technology offers solutions to all major problems now faced in the updatable microfiche system. This new technology will also provide additional capabilities such as image transmission, direct multiple access to OMPF information, substantial increased speed of retrieval for OMPF information, image enhancement, potential for merging image and data information systems, and automatic data extraction from image information.

While it is clear that the technology is in its infancy, systems are currently being developed and marketed by a wide variety of different vendors -- in 1984, the Library of Congress will begin its pilot project utilizing a digital image system. Many more systems should be developed within the next two years.

RECOMMENDATION 4. A PILOT PROJECT USING DIGITAL IMAGE TECHNOLOGY SHOULD BE IMPLEMENTED PRIOR TO FULL-SCALE CONVERSION TO THIS NEW TECHNOLOGY.

Section 5.7 of this report provides detailed information regarding the development of a pilot project for the OMPF. A pilot project could be conducted during 1986 at a cost of approximately $1.85 million (1986 projected cost) for equipment, facilities, microfiche, software, and personnel. The knowledge

gained during the pilot project will result in system refinement and enhancement. Full-scale conversion can then proceed with confidence beginning in the 1987 time frame. The equipment will then be available for operational use at MILPERCEN after the conversion.

RECOMMENDATION 5. THE DEVELOPMENT OF THE DIGITAL IMAGE SYSTEM SHOULD REPRESENT A CONSOLIDATED PROJECT WHICH INCLUDES ALL FOUR FACILITIES.

One of the major shortcomings of the RAM2 project was that only MILPERCEN and EREC were included. Consequently, the National Guard and RCPAC had difficulty obtaining necessary funding for conversion; neither installation is fully converted at this time. In order for the Army to fully benefit from this new digital image technology, the development should occur almost simultaneously at all four sites following the pilot projects. All conversions could then proceed in a two- to three-year period between 1987 and 1989, and all four installations could be fully operational by 1990, or earlier.

RECOMMENDATION 6. THE PLANNING AND BUDGETING FOR THE DIGITAL IMAGE SYSTEM PILOT PROJECT AND SYSTEM DEVELOPMENT SHOULD BEGIN IMMEDIATELY.

Section 5.7 of this report suggests an implementation plan consisting of several steps leading to the conversion to a digital image system at all four sites. The plan calls for beginning each task as indicated below:

February 1984	-	Accept Project Report
	-	Budget pilot project and total system conversion
July 1984	-	Begin detailed systems design
April 1985	-	Select systems integrator
	-	Final systems design
	-	Equipment selection
	-	Programming
December 1985	-	Implement and test system
1986	-	Operate and evaluate pilot project
1987	-	Complete pilot project conversion
1988-90	-	Convert other sites

Due to the many steps in the process and the need to carefully evaluate this new technology, plans to develop a detailed systems design should begin by mid-1984. Since the Army requires long-range budgets, these budgets should be prepared and submitted as soon as possible to include all components of systems design, the pilot project and the total system conversion. After the detailed systems design has been completed, budgets can be revised as necessary to better conform to expected system costs.

RECOMMENDATION 7. A DIGITAL IMAGE TECHNOLOGY COMMITTEE SHOULD BE ORGANIZED CONSISTING OF REPRESENTATIVES FROM ALL FOUR INSTALLATIONS, THE ADJUTANT GENERAL'S OFFICE, AND OTHER ORGANIZATIONS WITHIN THE ARMY WHICH HAVE AN INTEREST OR A NEED TO PROVIDE INPUT INTO THIS PROJECT.

The digital image technology committee should be formed as soon as possible and develop a schedule for regular meetings and accomplishments. In order to ensure the success of the committee and the subsequent system development, the

committee should include representatives from all organizations within the Army who will be users or whose cooperation will be needed to develop an effective system. The committee could operate on two levels: an Executive Committee and the full committee. The Executive Committee should include representatives from the four installations and ODCSPER (see Recommendation 9). The Executive Committee would be responsible for ensuring that all project activities proceed on schedule and that the expected results are achieved. The full committee will meet periodically to provide advice and consent to the development of the digital image system.

RECOMMENDATION 8. THE DIGITAL IMAGE SYSTEM SHOULD BE DEVELOPED BY ARMY PERSONNEL WITH RECORDS MANAGEMENT AND MICROGRAPHICS EXPERIENCE, WITH SUPPORT SERVICES PROVIDED BY DATA PROCESSING PERSONNEL.

Although the digital image technology involves computers, the technology deals primarily with images and not data. The existing managers and supervisors for the OMPF micrographics system have extensive experience with the management of images and user needs for images. Very few data processing personnel have any experience with images or with this new technology. It is, therefore, recommended that the primary decision makers for the digital image systems development have records management and micrographics experience and expertise and that data processing personnel provide the support services necessary.

RECOMMENDATION 9. THE DIGITAL IMAGE SYSTEM SHOULD BE DEVELOPED UNDER THE AUSPICES OF THE OFFICE OF THE DEPUTY CHIEF OF STAFF FOR PERSONNEL (ODCSPER).

As indicated in Recommendation 5, the digital image system should be developed as a consolidated project, including all four installations. The Army chain of command is not structured to permit this type of joint system development, other than through voluntary cooperation. The ODCSPER represents the first position in the Army's organization chart to exercise control over all four personnel systems. In addition, it would be most advantageous to have the support of high ranking officials in the Army to develop an effective Army-wide system, and to help obtain the large budgets needed for the conversion.

RECOMMENDATION 10. A DETAILED SYSTEMS DESIGN SHOULD BE DEVELOPED IN 1984.

This report constitutes an evaluation of the existing OMPF system and provides a very preliminary systems design for the digital image system. By the Summer of 1984, work should begin on the development of a detailed systems design to include system specifications, operating procedures, detailed cost analysis, and project schedules for both the pilot project and the subsequent system conversion. It is anticipated that an outside contractor will be hired to undertake the detailed systems design project; a request for proposal must therefore be ready by late Spring 1984. The results of the detailed systems design will be incorporated into a request for proposal for the selection of a systems integrator to develop the digital image system for the pilot project.

RECOMMENDATION 11. A SYSTEMS INTEGRATOR SHOULD BE SELECTED TO DEVELOP THE DIGITAL IMAGE SYSTEM FOR THE PILOT PROJECT. THE SAME SYSTEMS INTEGRATOR OR ANOTHER MAY BE SELECTED FOR DEVELOPING THE FULL SYSTEM FOR CONVERSION AND OPERATION.

Due to the complexity of the digital image technology and since no one company manufactures all components of the system, it is not expected that the Army will be able to develop the internal expertise to select the equipment, integrate the system, and develop the appropriate software within the time-frame recommended for system development. Several existing firms function as systems integrators for this technology; several other firms will become active in this field during the next few years. The Library of Congress, for example, chose a systems integrator for their pilot project. The systems integrator will normally obtain all necessary equipment at OEM prices and sell it to the client at retail prices. The advantage of using a systems integrator, however, is that the systems integrator is responsible for the entire system, including operation and maintenance, resolving problems of compatibility and "finger pointing" which often occurs in systems with multiple vendors.

RECOMMENDATION 12. THE ARMY SHOULD DEVELOP STAFF EXPERTISE IN DIGITAL IMAGE TECHNOLOGY OR A LIAISON SHOULD BE OBTAINED BY CONTRACT TO REPRESENT THE ARMY IN DEALINGS WITH THE SYSTEMS INTEGRATOR.

The systems integrator is in an unusual position: the integrator is both a consultant and a vendor. As such, it is expected that the systems integrator may not always reflect the views of the Army in systems development. Due to the complexity of the technology, however, the Army may not be in a position to determine problems with the system design, integration, or operation, without additional expertise representing its position. The Army may determine it desirable to immediately begin developing an in-house staff of experts in digital image technology. This may prove difficult since the technology is so new, very few individuals have training in this area, and those individuals with experience command extremely high salaries. The development of in-house expertise, although difficult, represents the best opportunity for the Army to insure that future system development meets its needs, and to develop the internal staff needed for future system development and enhancement. In this way, the Army can reduce its reliance on the systems integrator and utilize its own resources. Alternatively, the Army could retain a consulting firm with expertise in digital image technology to represent the Army's interest in systems development. Regardless of the approach taken, the systems integrator or liaison consultant will be responsible for helping the Army improve its own expertise in this field.

RECOMMENDATION 13. NEW DEVELOPMENTS IN THE FIELD OF DIGITAL IMAGE TECHNOLOGY SHOULD BE MONITORED ON A REGULAR BASIS.

The digital image technology committee, along with designated Army staff and liaison consultant, should carefully monitor all new developments in the field of digital image technology. Representatives should attend the major conferences held each year. Additionally, the Army should obtain subscriptions to all major periodicals and other services related to this industry. Periodic meetings should be held with vendors to determine their state of development. In particular, the Army should monitor the development of optical disk technology, image enhancement capabilities, raster COM unit developments, graphic

terminal costs, and data transmission systems using fiber optics. Progress must be made in these five areas before the Army can recognize full benefit from the new digital image technology. The Army should also monitor advances in artificial intelligence and intelligent programming techniques for discrete, rapid information retrieval.

RECOMMENDATION 14. THE DIGITAL IMAGE SYSTEM DEVELOPED MUST INCLUDE CAPABILITIES FOR PRODUCTION OF HIGH QUALITY IMAGES AND PROVIDE FOR IMAGE ENHANCEMENT.

One of the greatest concerns related to digital image technology is the ability of the system to produce high quality images. When good quality originals are involved, the system must produce extremely good quality images in a production mode. Image enhancement capabilities such as those discussed in Section 5.4.2 of this report must be provided to enhance poor quality images, microfiche images converted to the new system, and photographs. The system must balance gray scale requirements and scanning resolution with storage requirements, and utilize image enhancement capabilities without having a negative impact on production.

RECOMMENDATION 15. HIGH SPEED IMAGE TRANSMISSION CAPABILITIES SHOULD BE PROVIDED WITHIN LOCAL AREA NETWORKS AND THE DEFENSE DATA NETWORK FOR DIGITAL IMAGE TRANSMISSION BEING DEVELOPED BY PROJECT 80X AND OTHER DATA PROCESSING PROJECTS.

Section 5.2.3 reviews the problems related to the local area network for MILPERCEN and the Defense Data Network. While data communications speeds of 56,000 bps are considered desirable for data processing, these speeds are unacceptable for image processing. As indicated in that section, at those speeds, over 12.5 minutes would be required to transmit a simple 50-page OMPF record. For a few records, the data transmission speed would be acceptable; but for the large number of anticipated records transferred between installations, the slow speed is unacceptable for image transmission. Unless higher speed transmission media is used, such as fiber optics, digital images will normally have to be transferred between installations by mail using optical disk or magnetic tape.

RECOMMENDATION 16. HIGHLY QUALIFIED STAFF ARE REQUIRED TO OPERATE AND MANAGE THE DIGITAL IMAGE SYSTEM.

Section 5.5.3(d) describes staff requirements to operate a typical digital image system. Many staff functions for the system require considerable judgment, knowledge of computers and system algorithms, and substantial knowledge and experience. This technology differs dramatically from both micrographics and traditional data processing. Fewer people are required to operate the digital image system than the micrographics system, provided that these are the "right people." New positions must be developed for this technology and salary scales approved which are commensurate with the skills required. After conversion, the entire personnel cost budget for this function will be substantially less than would otherwise be required to operate the micrographics system.

8.2 EXISTING OMPF MICROGRAPHICS SYSTEM -- GENERAL RECOMMENDATIONS

RECOMMENDATION 17. A SYSTEM SHOULD BE DEVELOPED FOR THE AUTOMATIC CAPTURE OF PERSONNEL DATA AT THE SOURCE.

The Army currently follows a cumbersome process of completing forms using standard typewriters, extracting data using labor intensive data entry techniques, and then storing the image of the information in the OMPF microfiche system. Instead, the Army should explore the potential for data entry of information at the source, either from the field or headquarters installation. In this way, the information could be entered directly into the SIDPERS system and transferred electronically to the microfiche system, if appropriate. Since this alternative will probably not be developed in the near future, the preprinted forms should be redesigned to facilitate automated data entry using OCR readers.

RECOMMENDATION 18. ALL PRE-PRINTED ARMY FORMS SPECIFIED BY AR640-10 FOR THE OMPF SHOULD BE REDESIGNED TO FACILITATE DATA EXTRACTION AND CHARACTER RECOGNITION.

The existing pre-printed Army forms included in the OMPF should be reviewed and revised as follows:

- All standard information such as name, Social Security Number, rank, date, etc., should be placed in the same location on every form.
- The form number should be printed using OCR readable fonts or bar codes.
- The preprinted information should be printed in a color, such as red or light blue, which is invisible to OCR readers.
- Special OCR symbols should be added to the form to facilitate the location and scanning of appropriate fields of information.

RECOMMENDATION 19. STANDARDIZED TYPEWRITER FONTS, COMPATIBLE WITH OCR INPUT, SHOULD BE REQUIRED FOR ALL FORMS.

Forms are now completed using a great number of typewriter fonts, some extremely difficult to read. While it is understood that Army units may be stationed in areas where electricity is not available, it is expected the headquarters offices will have access to electric typewriters to complete standardized forms for the OMPF. Since most OCR readers can now recognize a variety of fonts, standard OCR-A or OCR-B are not necessarily required. (See ANSI X3.99-1983, Optical Character Recognition, for guidelines for OCR print quality.) The standardization of fonts will also help to improve the quality of the image. Since electric typewriters must be used to fulfill the requirements of this recommendation, additional advantages will result from the sharp, even impression obtained and the use of carbon ribbons instead of fabric. The Department of the Navy now uses OCR-readable forms to facilitate data entry of information in the personnel system.

RECOMMENDATION 20. ORIGINAL DOCUMENTS SHOULD BE SUBMITTED FOR FILMING ON THE OMPF MICROFICHE.

Many documents received for filming are duplicate copies of the original--often extremely poor reproductions. Since the OMPF microfiche is the "official" personnel record, the original should be submitted for filming, rather than retained in the MPRJ or by the individual. The use of originals will substantially improve the image quality and help improve the effectiveness of the microfiche system.

RECOMMENDATION 21. THE MILITARY PERSONNEL OFFICES (MILPO'S) SHOULD BE INSTRUCTED TO COMPLY WITH AR640-10, AND SUBMIT ONLY REQUIRED DOCUMENTS FOR THE OMPF.

Substantial personnel time is wasted at each installation screening documents which are inappropriate for the OMPF. Personnel at the MILPO's should be provided additional training, written instructions, and personal letters requesting their cooperation in sending only OMPF documents. This will save time both at the microfilm installations and at the MILPO.

RECOMMENDATION 22. AN INSPECTION AND QUALITY CONTROL PROGRAM SHOULD BE DEVELOPED FOR MICROFICHE DUPLICATES.

Currently, all installations produce poor quality duplicate microfiche. No effective inspection and quality control programs have been developed. An inspection and quality control program for microfiche duplicates should include the following:

- Assignment of responsibility for the program to specific individuals.
- Maintenance of quality control standards requiring the D-min to be within the range of .05 to .15 and the D-max within the range 1.05 to 1.15, producing a Delta-D of 1.0 ± 10%. Production of duplicates should cease and corrective measures taken, if the test results deviate from these standards.
- Duplicators should be checked by testing a duplicate at least once per shift and a log maintained to indicate date, time of inspection, operator name, duplicator number, exposure time, developer temperature, D-max, and D-min.
- Staff should coordinate more closely with film and equipment vendors to insure that the best quality output is achieved.

Section 3.2 contains additional information on duplication.

RECOMMENDATION 23. WHITE COTTON GLOVES SHOULD BE UTILIZED BY INDIVIDUALS HANDLING THE ORIGINAL MICROFICHE.

While many staff members handling the original microfiche are extremely careful not to touch the image area, it is apparent that some staff do not handle the microfiche as carefully and fingerprints do get on the image area of the fiche. Cotton gloves should be mandatory for duplication operators, and

are desirable for inspection and camera operators. The gloves represent consumable supplies which should be discarded and replaced when dirty; washing of gloves is not recommended due to the inconvenience and the chance of undesirable chemicals remaining in the gloves.

RECOMMENDATION 24. LABELS FOR THE ORIGINAL MICROFICHE SHOULD BE PRINTED USING DENSE BLACK, INDELIBLE INK.

The typing on many labels in the system has smeared or dulled over time. This makes it extremely difficult to read the information, especially on duplicates. Labels should have a clear, transparent background, and labels with errors should be discarded and retyped. When typewriters or character printers are used, non-correctable carbon film ribbon should be used. When high-speed computer printers are used with cloth ribbon, the ribbon should be changed frequently to ensure a dense black image.

RECOMMENDATION 25. READERS AND READER-PRINTERS SHOULD BE CLEANED AND INSPECTED WEEKLY. READERS USED FOR BOARDS SHOULD BE CLEANED AND INSPECTED DAILY.

Many of the readers and reader-printers examined were not functioning properly. Specific staff members should be assigned to inspect the readers and reader-printers at least weekly and perform necessary in-house maintenance. Readers which are used frequently, such as those used by Boards, should be inspected on a daily basis.

RECOMMENDATION 26. A STANDARD PROCEDURES MANUAL SHOULD BE DEVELOPED TO DOCUMENT EVERY STEP OF THE OPERATION.

No standard procedures manual exists. A standard procedures manual is extremely important to insure that procedures are uniformly followed by all staff, facilitate training of new staff, insure continuity of the system and resolve questions without the need to disturb others. All employees should be provided with a copy of the procedures manual. To facilitate the updating process, the text of the manual should be prepared using word processing equipment.

RECOMMENDATION 27. PRODUCTION STANDARDS, INCLUDING QUALITY AND QUANTITY, SHOULD BE DEVELOPED FOR EACH OPERATION. DETAILED STATISTICS ON PRODUCTION SHOULD BE MAINTAINED.

Production standards should be developed for all operations to facilitate the production of the microfiche records in a timely manner. Employee reviews and merit raises should be based, in part, on adherence to these published standards. By including production as well as quality standards, each employee is provided notice as to specifically what is required. Statistics and production charts for each function should be posted in a visible area in order to make productivity a more competitive and desirable goal. Productivity standards should be reviewed periodically as procedures are streamlined, staff better trained, and volume increases. Detailed statistics on production should be maintained and used to determine problem areas, modify staff assignments, and plan for future systems and system changes.

RECOMMENDATION 28. STAFF SHOULD BE CROSS-TRAINED IN ALL ASPECTS OF THE OMPF MICROFICHE SYSTEM AND SHOULD PERIODICALLY WORK IN OTHER AREAS.

By cross-training staff, managers can better allocate personnel to meet existing needs. Through the performance of varied tasks, it is hoped that morale will be improved and fatigue reduced, resulting in reduced absenteeism and turnover. Cross-training would also provide backup for absent employees. Although it may be appropriate to designate certain individuals as specialists in performing certain functions due to both their ability and desire, these individuals should still periodically be transferred to perform other functions within the system.

RECOMMENDATION 29. SUPPLY STOCKS OF DUPLICATE AND ORIGINAL FILM SHOULD BE TESTED UPON RECEIPT AND ROTATED TO INSURE THAT THE OLDEST STOCK IS USED FIRST.

When a new shipment of original or duplicate film is received, a sample should be removed from each batch and tested in operation as soon as possible. If any sample fails to meet standards, the entire batch should be returned for credit. Batches should also be carefully rotated to ensure that the oldest stocks are used first.

RECOMMENDATION 30. MANAGEMENT CONTINUITY SHOULD BE PROVIDED AT EACH FACILITY.

Two of the four facilities are managed by civilian personnel while the other two by military personnel. Since the Army rotates field assignments periodically (generally within three years), there may well be a lack of continuity in managing and operating the system. This could hamper the development process of the existing system and future systems. It is therefore recommended that a civilian be assigned responsibility for managing the system operation. Military officers would still have a significant role to play in overseeing the manager, system development, system philosophy and policy, and dispute resolution; but the desired system continuity would still be maintained.

RECOMMENDATION 31. THE PRODUCTION AND DISTRIBUTION OF DUPLICATE COPIES SHOULD BE REDUCED WHENEVER POSSIBLE.

The production and distribution of duplicate copies places a severe strain on the system operation, including personnel, supply costs, and access to the original updatable microfiche. Automatic distribution of copies to the Career Management Branch, for example, seems wasteful since the microfiche is rarely used, and copies of the evaluation reports and most other information are maintained in paper form in the Career Management files. Other instances of wasteful or unnecessary duplicates should be carefully examined.

RECOMMENDATION 32. AN EXPERIMENT SHOULD BE CONDUCTED TO UTILIZE LOW POWER LIGHT BOXES AND 10X EYE LOUPES IN PLACE OF READERS FOR INSPECTION OF THE ORIGINAL MICROFICHE.

The current inspection procedure requires that the original microfiche be placed in a reader for inspection. Substantial production time is lost loading the

microfiche into the carrier and positioning to the last frame filmed, and the original can easily be damaged. In addition even a reader with a filter recommended by A.B. Dick will still emit intense, harmful light. The use of a light box would certainly increase inspection speed and may reduce the amount of harmful exposure to intense light of the original microfiche. The impact of this inspection method should be discussed with experts at A.B. Dick.

RECOMMENDATION 33. COMPUTER SYSTEMS SHOULD BE ENHANCED TO PERMIT COMPUTER CONTROL OF THE ACCESS-M UNITS.

The computer systems of both RCPAC and the National Guard are programmed to control retrieval from the M-Unit; the computer systems at EREC and MILPERCEN do not have this capability. It is recommended that all computer systems be programmed to control retrieval from the M-units by sorting requests by M-unit and cartridge, and retrieving carriers in the optimal order.

RECOMMENDATION 34. AN EXPERIMENT SHOULD BE CONDUCTED UTILIZING THE AUTOMATIC DELIVERY SYSTEM FOR THE ACCESS-M SYSTEM USED BY THE NATIONAL GUARD.

The National Guard has Access-M units equipped with the Automatic Delivery System which will automatically eject the requested carrier into a bin. When used in conjunction with computer-assisted retrieval recommended above, this feature could substantially enhance productivity, especially when retrieving records for Board review. The National Guard should provide information to the other facilities as to the effectiveness of this capability. In the event that the system functions as expected, it is recommended that the other facilities update their systems with this feature.

RECOMMENDATION 35. THE COMPUTER SYSTEMS AT ALL FACILITIES SHOULD BE INTEGRATED WITH EACH OTHER AND WITH OTHER PERSONNEL COMPUTER SYSTEMS IN THE ARMY.

Currently, each installation operates its own stand-alone computer system. It is recommended that the computer systems at all sites be enhanced to enable direct data communication between sites in order to facilitate the transfer and retrieval of information.

RECOMMENDATION 36. A UNIFORM COMPUTER SYSTEM DESIGN SHOULD BE DEVELOPED AT ALL INSTALLATIONS.

Each installation currently operates its own unique computer system to assist in managing the OMPF microfiche system. Since three different computers are used, the software is incompatible. The review of the system, however, indicated that all installations function essentially the same way. Substantial time and money could be saved, and operations improved more quickly, if the same software could be developed and shared by all installations. While this would be ideal, it may be impractical since several new expensive computers would be required. Alternately, the installations could work to develop a uniform computer systems design, specifying all the requisite functions of the software programs. Each installation would then be able to translate the design into the appropriate computer language with reduced programmer requirements.

RECOMMENDATION 37. PROGRAMMING SUPPORT SHOULD BE PROVIDED AT EACH FACILITY FOR THE COMPUTER CONTROL SYSTEM.

Since all the computer systems require modification periodically and operations could be improved with some new software, it is recommended that programming support be made available to each facility to meet these needs. These needs can best be met by having programmers on staff, where not already present.

RECOMMENDATION 38. THE WORKING ENVIRONMENT SHOULD BE ENHANCED THROUGH IMPROVEMENTS IN LAYOUT, REDUCTION OF HUMIDITY, NOISE, TEMPERATURE CONTROL, AND VENTILATION.

In all installations, environmental problems were encountered which invariably impact on worker comfort and productivity. Humidifiers are generally required, especially in the winter. Carpeting is recommended at all sites to minimize discomfort while walking on concrete floors and to absorb noise. Noise can also be reduced by using drapes, acoustic panels, and ceiling tiles. The heating and air conditioning systems must be adequate to maintain a comfortable temperature even when equipment is fully operational. Finally, the ventilation system must be adequate, especially around the duplicator, to properly vent ammonia fumes and other irritants from the air.

RECOMMENDATION 39. AN EXPERIMENT SHOULD BE CONDUCTED UTILIZING NEGATIVE DUPLICATES FOR THE BOARDS IN PLACE OF THE POSITIVE DUPLICATES NOW PROVIDED.

The results of the questionnaire provided to Boards are described in Chapter 2. Most Board members indicated that their eyes were tired after reviewing the microfiche records all day. In addition, the results indicated that the bright light emanating from the background of the positive microfiche image may be a cause of discomfort. A negative microfilm image (light letters on a black background) would reduce the amount of bright light shining in the eyes of the Board members.

Negative duplicates can be produced using vesicular film in place of the current diazo film. A vesicular duplicator should be obtained on a loan or lease basis for testing, probably with the help of TAG. It is suggested that an experiment be conducted with one or more selection Boards to determine their preference in terms of negative or positive film. A follow-up questionnaire should be prepared to determine their attitudes regarding the ease of use, impact on eyestrain, image sharpness, and preference related to both negative and positive film. The scope of the test should be large enough to adequately determine the board's preference. If the results substantially favor negative film, new vesicular duplicators will be required. Existing reader-printers have controls to permit production of positive prints from negative images.

RECOMMENDATION 40. ERGONOMIC WORK STATIONS SHOULD BE PROVIDED FOR BOARDS.

The work stations provided for selection Boards are not adequate considering the tedious task performed. Board members complain of eyestrain, stiff necks, sore backs, sore arms, and other problems which substantially detract from

their ability to concentrate and make appropriate judgments. Considering the importance of the decisions made by selection Boards (impacting the careers of individuals and huge budgets) and the cost of constituting a Board each day, the expenditure to provide appropriate facilities for the Boards is clearly cost justified.

Each Board member should be provided with an ergonomic work station to improve comfort and permit the adjustment of equipment and work surfaces to the optimal height and tilt. See Section 3.3 for additional detail regarding the ergonomic work station and high quality readers.

RECOMMENDATION 41. BOTH SIDES OF THE EVALUATION REPORT SHOULD BE FILMED ON THE SAME ROW OF THE MICROFICHE.

Several Board members complained in the Board Questionnaire that it is difficult to review an evaluation report when the front side is filmed as the last frame of one row and the back side as the first frame of the next. They recommend that both sides be filmed on the same row to facilitate review. A blank image might therefore be required as the last image in a row, if an evaluation report will be filmed next.

RECOMMENDATION 42. EFFECTIVE PROCEDURES SHOULD BE DEVELOPED TO CONTROL THE TRANSFER OF RECORDS BETWEEN INSTALLATIONS AT SEPARATION TO RCPAC AND THE TIMELY RETURN OF THESE RECORDS TO THE INSTALLATION IN CASE OF REENLISTMENT OR REACTIVATION.

Problems continue to exist when records are transferred to RCPAC at separation, and the individual re-enlists or is reactivated. In many cases, the separation records cannot be located during the first 90-120 days after transfer to RCPAC. An improved tracking system must therefore be developed for these records, and the backlog for processing these records at RCPAC must be reduced, perhaps through the addition of more staff.

8.3 EXISTING OMPF MICROGRAPHICS SYSTEM -- SPECIFIC RECOMMENDATIONS BY SITE

8.3.1 MILPERCEN

RECOMMENDATION 43. PROCEDURES SHOULD BE DEVELOPED TO FACILITATE RETRIEVAL OF MICROFICHE RECORDS REQUESTED BY THE CONVENIENCE UNIT TO FULFILL SPECIAL REQUESTS.

Currently, the Convenience Unit has difficulty getting access to the M-units to retrieve necessary microfiche to respond to special requests. New procedures should be developed to enable the Convenience Unit to get faster access to this information. When computer control for the M-unit is developed, the requests by the Convenience Unit can be handled automatically as a batch periodically during the course of the day.

RECOMMENDATION 44. A HIGHER QUALITY COPIER SHOULD BE PROVIDED TO THE PRE-INSPECTION UNIT TO REDUCE OVERSIZED DOCUMENTS PRIOR TO FILMING.

The pre-inspection unit is responsible for reducing oversized documents to letter size prior to filming. Some copies now created reproduce poorly on the microfilm. It should be noted that the "original" received by the pre-inspection unit may already be a poor quality copy itself. The actual image on the microfiche may then be the third or fourth generation from the original.

8.3.2 EREC

RECOMMENDATION 45. ADDITIONAL M-UNITS SHOULD BE OBTAINED TO ELIMINATE CONGESTION OF THE EXISTING MICROFICHE STORAGE UNITS AND TO PERMIT REDUCTION IN THE BACKLOG FOR ACCESSIONS.

All M-units at EREC contain 50,000 to 55,000 carriers per unit. While Access recommends no more than 33,000 carriers per unit, practical experience has shown that the system will function appropriately with up to 40,000 carriers per unit. As a result of overcrowding, a large number of carriers cannot be located when requested (responding in a "not-in-file" condition), resulting in a large number of hand searches. This is particularly wasteful since the advantage of automated retrieval from the M-unit is lost and production is substantially reduced. There is currently not sufficient space to store the microfiche for accessions, even when the backlog is reduced. It is therefore recommended that 3 additional M-units be provided at EREC.

RECOMMENDATION 46. ALL ORIGINAL MICROFICHE SHOULD BE INSPECTED AFTER FILMING.

Currently, 30% of microfiche for E6 and above are inspected; practically no inspection is provided for microfiche for the other ranks. Additional staff should be obtained, if necessary, to enable EREC to inspect all microfiche produced. This will insure that good quality images are being produced prior to the destruction of the paper records.

RECOMMENDATION 47. BACKLOGS FOR ACCESSIONS SHOULD BE REDUCED TO SEVEN MONTHS AND BACKLOGS FOR UPDATES ELIMINATED FOR E5 AND BELOW.

Updates for E6 and above are handled within one week of receipt. However, accessions and updates for E5 and below are backlogged up to 13 months. The backlog resulted partially from the conversion from power files to Access-M units of 200,000 records. Another source of backlog has resulted due to limitations of staff size. The backlog, however, creates a great number of problems in the operation of the system such as:

- Boards receive incomplete microfiche records since some documents have not reached the filming stage.

- Some documents reach the filming stage prior to the creation of the original microfiche from the accession records. In this case, the production operation is disrupted while a hand search is conducted

for the accession records and an original microfiche is made using an exceptional process.

- Documents submitted to the OMPF for update are "in limbo" for the backlog period and cannot be located.

EREC recommends that the backlog for accessions be established at seven months since a large number of the enlisted individuals are separated prior to that period and it would be wasteful to create an original microfiche in those cases. Updates for records already accessioned (for which the original microfiche already exists) should be separated from updates for non-accessioned records. These records should be updated more frequently. Additional staff will be required to reduce the backlog.

8.3.3 NGB

RECOMMENDATION 48. A CENTRALIZED OMPF MICROFICHE SYSTEM SHOULD BE DEVELOPED FOR RECORDS OF ENLISTED NATIONAL GUARD PERSONNEL MAINTAINED BY THE STATES.

The National Guard Bureau is exploring the potential for developing a centralized OMPF microfiche system for enlisted personnel records maintained by the states, similar to the existing officer records system. The development of a centralized OMPF system for enlisted records is extremely important for managing that component of the total force in case of mobilization. No standards are currently followed by the 50 states and 4 territories. As such, the centralized system would also impose a degree of standardization on the records system maintained by the state National Guard units.

RECOMMENDATION 49. PROCEDURES SHOULD BE DEVELOPED TO IMPROVE COMMUNICATION BETWEEN THE NATIONAL GUARD AND THE OTHER INSTALLATIONS RELATED TO THE TIMELY TRANSFER OF OMPF MICROFICHE TO THE NATIONAL GUARD.

The National Guard has experienced a problem since some new individuals to the National Guard were previously in the active Army or Reserves. Microfiche OMPF records may exist at RCPAC or MILPERCEN which are needed by the National Guard. In some cases the National Guard produces a new original microfiche and later must correct the microfiche when an original microfiche is finally received from another installation. Better procedures should be developed to eliminate this problem, including the direct access and sharing of computer data between installations.

RECOMMENDATION 50. ALL MICROFICHE CARRIERS SHOULD BE ENCODED BY THE MANUFACTURER.

The National Guard purchased a supply of microfiche carriers without encoding. They are required to now encode these carriers manually (using an encoding device) which requires substantial staff time. The net cost of purchasing the carriers already encoded is much less expensive.

RECOMMENDATION 51. THE CARD INDEXING SYSTEM CONTAINING INFORMATION ON SEPARATIONS SHOULD BE CONVERTED TO COMPUTER READABLE FORM.

The National Guard currently maintains an indexing system containing information related to name, Social Security Number, order number, date of separation, and other information. Since these cards are fairly uniform, the National Guard should explore the potential for converting this information into computer readable form using a sophisticated OCR device. The computer index could then be sorted as needed and produced on COM microfiche. The active index could be maintained on-line for retrieval. New index entries would be produced in computer-readable form using the Wang computer system. The elimination of the card file would reduce personnel time devoted to indexing and provide additional space for other functions.

8.3.4 RCPAC

RECOMMENDATION 52. PROCEDURES SHOULD BE DEVELOPED TO INSURE THAT THE MICROFICHE IS UPDATED WITH ALL DOCUMENTS IN THE POSSESSION OF THE INSTALLATION PRIOR TO TRANSFER OF THE SEPARATION PACKET TO RCPAC.

Currently, each installation updates the original microfiche with the DD-214 and then transfers the separation packet to RCPAC as soon as possible. At a later date, EREC will encounter documents which have been maintained "on the wall" related to a separated individual, and transfer those documents to RCPAC for updating. This procedure is extremely disruptive to RCPAC's operation. It is expected, however, that even after separation, the installations might receive new documents related to separated individuals, and be forced to transfer these to RCPAC for updating. In all fairness, all documents within an installation's possession should be filmed on the original microfiche before it is transferred to RCPAC.

RECOMMENDATION 53. THE DOCUMENTS MAINTAINED IN THE MILITARY PERSONNEL RECORDS JACKET (MPRJ) BY RCPAC SHOULD BE MICROFILMED AND THE PAPER DESTROYED.

RCPAC is the only installation required to maintain both a microfiche and paper filing system. This results because the MPRJ, consisting of medical and other field records, is in paper form. RCPAC also maintains records of retired individuals as required by the Army.

It is recommended that the paper MPRJ file be microfilmed within a reasonable period after receipt by RCPAC. A high-speed, high-quality step-and-repeat microfiche camera, such as TDC Documate II or equivalent, should be used to ensure adequate quality, especially for the medical records. The Surgeon General has expressed concern that microfilm will not adequately reproduce dental records. A test should be conducted to determine whether these concerns are valid. The Marines currently microfilm all paper records, including medical records, prior to retirement of the record at NPRC, and have not indicated any problems.

RECOMMENDATION 54. RCPAC SHOULD TRANSFER RETIREE RECORDS TO NPRC.

The Army is the only branch of the Armed Forces which maintains its own retiree records. These records are generally extremely thick, require substantial storage space, and disrupt record keeping functions for active records at RCPAC. In line with the procedures followed by the other branches of the Armed Forces, it is recommended that these retirement records be transferred to NPRC for maintenance and long-term storage. Although the Army prides itself in "taking care of its own," there appears to be no additional benefit derived by the Army managing these records rather than NPRC. NPRC will require funding and space to store the records.

RECOMMENDATION 55. THE INTEGRATED DOCUMENT CONTROL SYSTEM (IDCS) COMPUTER SYSTEM DEVELOPED BY ACCESS SHOULD BE MODIFIED TO SORT RECORDS FOR RETRIEVAL BY UNIT NUMBER AND THEN BY CARTRIDGE NUMBER.

The existing IDCS computer system will only sort records for retrieval by unit number. As such, cartridges are retrieved in a random order. In some cases, an individual tray is retrieved several different times during the course of the search. In order to streamline and speed up the operation, all carriers stored in an individual cartridge should be retrieved at the same time. Changes in the software program would be required to accomplish this. It would be desirable to have a staff programmer available to make this software change and to develop new applications needed to improve the system, or Access can make the necessary changes under contract.

RECOMMENDATION 56. PROCEDURES SHOULD BE DEVELOPED TO FACILITATE THE RETRIEVAL OF REQUESTS BY SYSTEM USERS.

Problems currently exist in production of duplicate copies of the OMPF record for outside users, especially Personnel Services. Over 40% of requests for the original microfiche result in an "out-of-file" response. The entire operation should be carefully reviewed to determine the reason for such a large out-of-file condition. The management of requests should also be modified to ensure that requests for duplicates will be handled immediately after the original microfiche has been located.

RECOMMENDATION 57. COLORED OUT-CARDS SHOULD BE PLACED IN THE LEKTRIEVER TO INDICATE THE LOCATIONS FROM WHICH MICROFICHE CARRIERS WERE REMOVED.

RCPAC is experiencing substantial difficulty with management of microfiche carriers in the 14 Lektriever units. When out-cards are used, the operator knows exactly where to refile the microfiche carriers. No writing is required on the out-card due to the production requirements for this application.

RECOMMENDATION 58. COLOR CODED CARRIERS SHOULD BE USED TO FACILITATE REFILING THE CARRIERS IN THE PROPER LEKTRIEVER.

Color coding will facilitate refiling the carriers in the proper Lektriever. The carriers can either be color coded to indicate a specific unit or to indicate a specific tray in the unit. Terminal-digit color coding may be the most effective.

RECOMMENDATION 59. THE COSTS AND BENEFITS OF ADDING ADDITIONAL M-UNITS TO REPLACE THE LEKTRIEVERS SHOULD BE REVIEWED.

RCPAC would require 4-5 M-units to replace the 14 Lektrievers; these units would cost over $1 million. The two recommendations above may help to reduce the problems with using the Lektriever. Before a commitment is made for new units, however, the need should be carefully studied to determine if such a large expenditure would be justified, especially with the prospects of converting to a new technology within 5 years.

RECOMMENDATION 60. BLUE LIGHTS SHOULD BE USED IN THE STORAGE AREA FOR THE LEKTRIEVER UNITS.

Lektriever units are now maintained in an area with white light. It was evident that the top portion of some microfiche in an exposed tray have turned a gray tone, indicating a loss of updating capabilities due to exposure to light. While the microfiche paper carrier and the tight compaction of the fiche in the tray may have prevented additional damage due to exposure, prolonged exposure to direct, unfiltered, light could potentially be harmful to the microfiche. The blue light will reduce possible future damage.

8.4 SPECIAL APPLICATIONS

8.4.1 Awards Branch

RECOMMENDATION 61. THE GENERAL ORDERS SHOULD BE CONVERTED TO 16MM ROLL FILM CARTRIDGES, FILMED AT 24X REDUCTION.

Roll film is recommended since all documents are organized in General Order number sequence, by date; information will be retrieved from the General Orders by date. Retrieval for this application will be much faster with roll film than microfiche. Misfiles are impossible with roll film, while they frequently occur with microfiche. Filming may be performed by a service bureau or the Army utilizing a high resolution planetary camera, such as Kodak MRD-2 or equivalent.

The filming cost estimates provided in Figure 7.1 were based upon the use of an outside service bureau for this one-time conversion. The work can also effectively be performed if the Army has in-house capabilities. Regardless of who performs the filming, it is critically important that the filming be performed on a high resolution planetary camera to provide the best quality image possible.

RECOMMENDATION 62. THE MICROFILM PRODUCED SHOULD MEET THE DEPARTMENT OF THE ARMY REQUIREMENTS SPECIFIED IN AR 340-22. ALL FILM SHOULD BE INSPECTED TO INSURE THAT QUALITY STANDARDS ARE MET.

The Department of the Army microfilm standards (AR 340-22) will ensure an extremely high quality image; AIIM or ANSI standards can be used to fill voids in the Army standards. All film should be inspected prior to duplication and destruction of the paper to insure that a quality image has been obtained.

RECOMMENDATION 63. ALL IMAGES SHOULD BE BLIP ENCODED.

Blip encoding will not add any additional cost to filming and will provide the capability for using more automated retrieval equipment at a later date. The blip encoding, however, will not be used for retrieval purposes for the type of reader recommended.

RECOMMENDATION 64. EYE-READABLE FLASH CARDS SHOULD BE FILMED PRIOR TO THE FIRST DOCUMENT IN EACH OF THE FOLLOWING FILE SUBDIVISIONS: HEADQUARTERS, YEAR, AND MONTH.

Flash cards are a form of film indexing that subdivides the rolls of film and assists the user in locating the desired subdivisions of the roll. The location of flash cards and the approximate location on the roll (odometer reading) should be included on the cartridge label.

RECOMMENDATION 65. THE ORIGINAL SILVER FILM SHOULD BE MAINTAINED IN ROLLS IN ACID-FREE BOXES FOR ARCHIVAL STORAGE AT NPRC. THE DUPLICATE SILVER COPY IN CARTRIDGES WILL BE PROVIDED TO THE AWARDS BRANCH, AND DUPLICATE DIAZO COPIES WILL BE PROVIDED TO RCPAC AND THE NATIONAL ARCHIVES.

The original silver film should be maintained in archival storage, so that duplicate copies can be created as necessary. Silver halide duplicate copies will be provided to the Awards Branch since silver produces the best quality duplicates and many of the source documents are poor quality; diazo duplicates will be provided to RCPAC and the National Archives because diazo is less expensive, stronger, and still produces an adequate image. The paper records may be destroyed after the film has been inspected and has passed the quality control standards stated above.

RECOMMENDATION 66. AFTER THE MICROFILM OF THE AWARDS HAVE PASSED INSPECTION, THE PAPER SHOULD FIRST BE OFFERED TO THE NATIONAL ARCHIVES PRIOR TO DESTRUCTION.

There is no need to retain the paper documents once the information is on the microfilm and the film has passed quality control standards. The National Archives has indicated an interest in these records for long-term retention. Since a microfilm copy would be made available to the National Archives, they may prefer the microfilm copy to the paper. As a courtesy, the paper should still be offered to the National Archives.

RECOMMENDATION 67. CARTRIDGES FOR DUPLICATE FILM SHOULD BE COMPATIBLE WITH READER AND READER-PRINTER REQUIREMENTS AT THE AWARDS BRANCH, RCPAC, AND THE NATIONAL ARCHIVES.

The Awards Branch should verify what types of readers and r[illegible] printers will be used at RCPAC and the National Archives and insure that compatible cartridges are used for loading the film. The reader-printer selected by the Archives will determine which model cartridge is used for its duplicates.

RECOMMENDATION 68. THE CARTRIDGE LABEL SHOULD CONTAIN THE ROLL NUMBER, HEADQUARTERS, FIRST AND LAST GENERAL ORDER NUMBER AND DATE OF FIRST AND LAST GENERAL ORDER NUMBER ON THE ROLL AS WELL AS THE ODOMETER READING FOR EACH FLASH CARD FILMED.

The label on the microfilm cartridge will serve as an index to assist the user in rapidly locating the correct roll and approximate frame location within the roll. The label indicating the location of flashcards should be placed on the face of the cartridge that is exposed to the user. The roll number, headquarters, first and last general order number and dates should be placed on the end of the cartridge. A copier can be used to make duplicate sets. Labeling should probably be done by the Awards Branch.

Section 7.1.3(b) reviews the issue of other forms of indexing, including computer indexing. The cost of this type of detailed indexing cannot be cost justified since the expenditure would exceed $275,000. Therefore, no computer index is recommended for this application.

RECOMMENDATION 69. IMAGE ENHANCEMENT, USING COPIER REPRODUCTION, MAY BE USED ON A SELECTIVE BASIS FOR IMPROVING POOR QUALITY IMAGES.

Since the documents were generated under field conditions, some may be marginal in quality. Image enhancement using copier reproduction is labor intensive and adds to the cost of the conversion but may improve the readability of some images. A test should be conducted to determine whether or when copier enhancement may be appropriate. If poor quality images are filmed, the camera operator should stamp the document "Poor Original" prior to filming, to advise the user that the poor quality image was not a filming error.

RECOMMENDATION 70. TWO READER-PRINTERS, INCLUDING STANDS AND CARTRIDGE CAROUSEL, SHOULD BE ACQUIRED FOR THIS APPLICATION.

Two reader-printers should be acquired to permit multiple access to the file and to provide a backup in the event of mechanical failure. The carousel cartridge file unit will permit the user to access the total film file while seated at the reader-printer. This will significantly reduce the time required by film users to search and retrieve the necessary information.

8.4.2 Promotions Branch

RECOMMENDATION 71. A MICROFILM SYSTEM SHOULD BE DEVELOPED ACCORDING TO THE SAME SPECIFICATIONS PROVIDED ABOVE FOR THE AWARDS BRANCH EXCEPT THAT ONLY ONE DIAZO DUPLICATE COPY AND READER-PRINTER IS REQUIRED. MICROFILM CARTRIDGES SHOULD BE MAINTAINED IN A LOCKED CABINET FOR SECURITY. FLASHCARDS SHOULD BE FILMED PRIOR TO THE FIRST DOCUMENT FOR EACH BOARD, YEAR, AND MONTH.

All documents maintained by the Promotions Branch are organized by promotion Board, date, and officer name. All documents should be organized on the roll film in cartridge in that same sequence. Flash cards should be filmed prior to the first document for each Promotion Board, year, and month. No other index is required for this application. Since the information is confidential, microfilm should be kept in a locked cabinet. Microfiche copies of the OMPF record provided to the Board can also be maintained in these cabinets.

Figure 7.2 provides a cost estimate for this application. The original silver film should be stored at NPRC in the appropriate environment.

RECOMMENDATION 72. THE ARMY SHOULD SUPPORT THE PROPOSED 5-YEAR STATUTE OF LIMITATIONS FOR APPEALS OF BOARD DECISIONS AND RECONSIDERATION OF THE RECORD.

The Promotions Branch is required to maintain all records reviewed by Boards just in case the records are needed at a later time. With an effective 5-year Statute of Limitations, no future microfilm program would be required. (Note: Even if a 5-year Statute of Limitations was approved, several years and subsequent legal challenges would pass before the requirements of the statute would be established. The proposed microfilm program is still justified to meet current needs; future microfilming could potentially be avoided.)

Congress is currently at an early stage of reviewing the proposed statute. The Army should provide its support to the statute and submit supporting evidence indicating the substantial harm caused to the Army and the minimal potential harm to Army personnel, resulting from the lack of such a statute.

GLOSSARY

ACCESSION - Military term applied to a new record for an individual entering military service, or returning to service after separation.

BPI - (Bits per inch) The storage capacity of magnetic tape, stated in number of bits per inch.

BIMODAL - A method for storing digitized information in binary mode, using one bit, either 0 or 1, to represent one pixel, either white or black. See Bitonal.

BIT - Abbreviation for Binary Digit, the smallest unit of information recognized by computers, either 1 or 0.

BITONAL - A method for storing digitized images with each pixel interpreted as black or white (no gray scale) and stored in bimodal format. See Bimodal.

BYTE - A sequence of 8 adjacent bits that form a unit of information in the computer. A byte stores the information necessary to represent one character.

CHARGE COUPLED DEVICE - A solid state electronic device containing a large number of light (pixel) detectors which are capable of producing images for computer use.

D-MAX - The degree of opacity or blackness achieved by a microform image.

D-MIN - The degree of opacity or blackness inherent in the microform base.

FRONT PROJECTION - A type of microfilm reader in which the image is projected downward onto a reflective horizontal surface.

GIGABYTE - A billion bytes of data; 1×10^9

GRAPHICS TERMINAL - A high resolution video display terminal used to present images as well as text, generally capable of displaying 150 pixels per inch or higher.

GRAY SCALE - The measurement of levels of brightness between the extremes of black or white.

LOCAL AREA NETWORK - Data or image transmission system within a small geographic area such as within a building, or between nearby buildings.

M-UNIT - Storage device manufactured by Access Information Control Systems for microfiche that provides automated fiche retrieval and refiling.

MEGABYTE - A million bytes of data; 1×10^6

MEGAHERTZ - A data transmission rate of one million bits per second.

PIXEL - Contraction of "picture element": a discrete point in an image.

RANDOM ACCESS - A method of accessing stored information by going immediately to the record desired without having to access any prior numbered records.

RASTER - A series of pixels which comprises or forms a line across an image.

REAR PROJECTION - A type of microfilm reader in which the image is projected onto the back of a translucent vertical screen for viewing.

REFRESH RATE - The rate at which one image is repeatedly displayed on a video display terminal screen; generally the image is refreshed 30-60 times per second.

REMOTE AREA NETWORK - Data or image transmission system between widely separated installations.

RUN LENGTH ENCODING - An efficient coding system which keeps track of the places along a raster where a change from black to white or white to black occurs.

SYSTEMS INTEGRATOR - An individual or organization responsible for developing and packaging complete systems, including software, from components manufactured by different companies.

TERMINAL DIGIT - A method of filing information by the last digits of a number (rather than in sequence). Terminal digit will divide all the numbers into equal size groups.

THRESHOLD - A level of intensity which distinguishes between two or more states. For example, in digital image technology the threshold is set to determine which pixels will be considered black (1) and which white (0).

APPENDIX A

INTERVIEWS CONDUCTED

APPENDIX A. STAFF INTERVIEWS CONDUCTED

Army, Department of the

MILPERCEN

COL R. Lind, Chief, Management Support Division
COL J. Forgy, SIDPERS3
COL J. Rice, IRMO
LTC J. Ferry, Chief, Promotions Branch, MSD
LTC J. Hickman, Awards Branch, DCSPAL
LTC M. Hoherz, Colonels Div. OPD
LTC G. Turcotte, Chief, Officer Records Branch
LTC T. Wilder, CAPIII, EPD
MAJ T. Corcoran, Systems Integration Section, PERSINSD
MAJ M. McNeese, Project 80X, Phase II
MAJ H. Rangel, Promotions Branch, MSD
SGT C. Turner, Supervisor, Special Actions Unit, OPRB, MSD
Ms. M. Hill, Chief, Micrographics, OPRB, MSD
Ms. C. Howard, Pre/Post Inspection Clerk, OPRB, MSD
Mr. D. Hruza, Manning the Forces Automated Architecture
Mr. A. Jackson, Supervisor, Micrographics Section, OPRB, MSD
Ms. J. Lehmann, Supervisor, Convenience Unit, OPRB, MSD
Mr. A. Powell, Supervisor, Document Processing Unit, OPRB, MSD

EREC

COL R. Brooks, Commander
Mr. O. Mays, Chief, Records Maintenance Division
Ms. W. Hunter, Chief, Accessions/Special Records Branch
Ms. P. Stewart, Chief, Document Screening Branch
Mr. R. Weiss, Chief, Records Branch
Ms. M. Williams, Chief, Camera/Inspection Section
Ms. D. Lutes, Chief, Image Assignment Section
Ms. D. Clanton, Chief, Separation Records Transfer System Branch
Ms. L. Fields, Chief, Field Assistance Branch
SGM M. Loveday, D.A. Secretariat
Mr. R. O'Conner, Chief, Personnel Action Branch
Mr. F. Mahan, Resource Management Officer

Mr. R. Fluharty, Defense Investigative Service

NGB

CW4 W. Rose, Chief, Personnel Records Branch
SGT S. Mendez, Personnel Records, NCO

TAG

Mr. J. Hardy, Micrographics Management Division
Mr. J. Vos, Records Management Division

RCPAC

BG R. Zeltman, Commanding General
COL M. Willis, Director, Personnel Actions Directorate
LTC A. Gayle, Promotions Division
CPT P. Klover, Admin/Logistics Officer, Personnel Services Directorate
Ms. M. Greathouse, Supervisor, Special Actions Division, Personnel Services Directorate
Ms. E. Hines, Supervisor, Special Actions Division, Personnel Services Directorate
Ms. E. Ledbetter, Chief, Microfiche Services Branch
Mr. T. Pinter, Chief, Special Actions Division, Personnel Services Directorate
Mr. J. Slazinik, ADCS, Administration
Ms. W. Smith, Supervisor, Special Actions Division, Personnel Services Directorate
Ms. E. Tatum, Supervisor, Special Actions Division, Personnel Services Directorate
Mr. J. Zike, Chief, Micrographics Div.

NPRC

Ms. D. Haverman, Chief, Army Records Branch

Navy, Department of the

Mr. W. Hopkins, Chief, Records Branch, Naval Annex
Mr. D. Endicott, Naval Ocean Systems Center (NOSC), San Diego

Marines

COL Walter

Library of Congress

Mr. J. Price, Director, Digital Image System Development

Vendors

A. B. Dick Company

Mr. G. Lettis, National Sales Manager
Mr. R. Books, Marketing Manager
Mr. D. Winsby, Customer Systems Engineer

Access Information Control Systems

Dr. R. Kalthoff, President
Mr. J. Rokely, Vice President, Sales
Mr. B. Clark III, National Systems Manager

Broomall Industries

Mr. W. Schmidt, Marketing Manager

APPENDIX B

VENDORS CONTACTED

RESEARCH EFFORTS
OCTOBER - NOVEMBER 1983

S - site visit
D - demonstration
L - literature

A.B. Dick Company — S
Records Systems
5700 W. Touhy Ave.
Chicago, IL 60648
(312) 647-8800

Access Corp. — S
4815 Para Dr.
Cincinnati, OH 45237
(513) 242-4220

Agfa-Gevaert — D
275 North Street
Teterboro, NJ 07608

ALOS Micrographics Corp. — D
239 E. Plains Road
Walden, NY 12586

ANA Tech Corp. — L
5231 South Santa Fe Drive
Littleton, CO 80120

Anacomp, Inc. — L
100 Oceangate, Ste. 720
Long Beach, CA 90802

Bell & Howell — D
Business Equipment Group
6800 McCormick Rd.
Chicago, IL 60645

Biotec Systems — L
3158 Production Drive
Fairfield, OH 45014

Broomall Industries, Inc. — L
700 Abbott Drive
Broomall, PA 19008

Calcomp — L
P.O. Box 3250
Anaheim, CA 92801

Canon U.S.A., Inc. — L
One Canon Plaza
Lake Success, NY 11042

Connecticut Micrographics, Inc. — D
143 Rowayton Ave.
Rowayton, CT 06853

Consolidated Micrographics, Inc. — D
27631 LaPaz Rd.
Laguna Niguel, CA 92677
(714) 643-0400

Data Conversion, Inc. — L
2865 Metropolitan Pl.
Pomona, CA 91767

Datacopy Corporation — L
1070 East Meadow Circle
Palo Alto, CA 94303

Datagraphix — D
P.O. Box 82449
San Diego, CA 92138
(714) 291-9960

Dicomed Corporation — L
9700 Newton Ave. S.
Minneapolis, MN 55431

Dietzgen Corp. — L
250 Willie Road
Des Plaines, IL 60018

Eastman Kodak Co. — D
343 State St.
Rochester, NY 14650
(716) 724-4000

Extek Micrographics, Inc. — L
6955 Hayvenhurst Ave.
Van Nuys, CA 91406

Eye Communications
117 Hill Street
Hartland, WI 53029
(414) 367-3080
L

Fuji Photo Film USA, Inc.
350 Fifth Ave.
New York, NY 10118
L

Image Systems, Inc.
P.O. Box 2488
Culver City, CA 90230
(213) 390-3378
D

Imtec Equipment Inc.
3344 Mather Field Rd.
Rancho Cordova, CA 95670
(916) 363-3105
L

Info. Access Systems, Inc.
1520 Grove St.
Boulder, CO 80302
L

Information Design
1300 Charleston Rd.
Mountain View, CA 94043
(415) 969-7990
D

Info. International Inc.
5933 Slauson Ave.
Culver City, CA 90230
L

Integrated Automation
2121 Allston Way
Berkeley, CA 94704
(415) 843-8227
S

Interactive Systems
5500 South Sycamore Street
Littleton, CO 80120
(303) 797-2400
S

Intergraph Corp.
One Madison Industrial Park
Huntsville, AL 35807
(205) 772-2000
L

Karmac BV
P.O. Box 212
8200 AE Lelystad
The Netherlands,
D

Kleer-Vu Ind., Inc.
Kleer-Vu Jackets Div.
Kleer-Vu Drive
Brownsville, TN 38021
L

Kongsberg North America, Inc.
P.O. Box 40510
Houston, TX 77240
(713) 466-4881
L

KV Jackets
Kleer-Vu Drive
Brownsville, TN 38012
(800) 238-3966
L

Laserscan Ltd.
Cambridge Science Park
Milton Road
Cambridge CB4 4BH, England
L

Memcom International, Inc.
1041 W. Collins Ave.
Orange, CA 92667
(714) 771-0800
L

Micobra Corporation
176 King St., P.O. Box 1187
Hanover, MA 02339
L

Microfilm Data Systems, Inc.
2904 Orchard Pkwy.
San Jose, CA 95123
(408) 945-1681
L

Microfilm Enterprises Corp.
12 New Dover Rd.
East Brunswick, NJ 08816
(201) 257-5225
D

Microseal Corporation
2000 Lewis Ave.
Zion, IL 60099
L

Minolta Corporation D
Micrographics Division
101 Williams Drive
Ramsey, NJ 07446

Mnemos S
Crystal City Gateway II
1225 Jefferson Davis Hwy.
Crystal City
Arlington, VA 22202

Morgan Data Conversion, Inc. L
1988 Leghorn St.
Mountain View, CA 94043
(415) 965-0352

Motion Technology Corp. L
Mount Pleasant Drive
Aston, PA 19014
(215) 358-1600

NB Jackets L
4801 Fulton Ind. Blvd. SW
Atlanta, GA 30336
(404) 691-1030

NCR Corp. D
Micrographics Systems Div.
520 Logue Ave.
Mountain View, CA 94043
(415) 965-3700

Northwest Microfilm D
1600 67th Ave. North
Minneapolis, MN 55430
(612) 566-5950

Novamedia Corp. D
Box 25
Sierra Madre, CA 91024
(213) 798-3311

Optical Peripherals Lab L
1050 S. Academy Blvd.
Suite 138
Colorado Springs, CO 80910

Ozalid Corp. L
1000 MacArthur Blvd.
Mahwah, NJ 07430

Philipps Company L
W255 N499 Grandview Blvd.
Waukesha, WI 53186

Photographic Sciences Corp. D
Corporate Headquarters
770 Basket Road
P.O. Box 338
Webster, NY 14580
(800) 828-6489

Photomatrix Corp. D
2225 Colorado Ave.
Santa Monica, CA 90404
(213) 828-9585

Planning Resource Corp. L
1500 Planning Research Drive
McLean, VA 22102
(703) 556-1660

Ragen Information Systems D
9 Povete Ave.
North Arlington, NJ 07032
(201) 997-1000

Realist Micrographic Systems D
N93 W16288 Megel Drive
Menomonee Fall, WI 53051

Reference Technology L
1832 55th St.
Boulder, CO 80301

Retrix Systems, Inc. L
2832 Walnut Ave., Suite B
Tustin, CA 92680

Russ Bassett Company L
P.O. Box 249
8189 Bryon Rd.
Whittier, CA 90608

Sci-Tex America Corp. L
75-D Wiggins Ave.
Bedford, MA 01730

Sony D
9600 George Palmer Highway
Lanham, MD 20706
(301) 577-4850

Storage Technology Corp. L
2270 S. 88th St.
Louisville, CO 80028

Systems Group of Colo., Inc. S
8800 E. Arapahoe Road
Englewood, CO 80112
(303) 741-1826

Tektronix, Inc. L
P.O. Box 1700
Beaverton, OR 97075
(503) 644-0161

Tera Info. Engineering Corp. D
2150 Shattuck Ave.
Berkeley, CA 94704
(415) 845-5055

Terminal Data Corporation S
Sales/Marketing
21221 Oxnard Street
Woodland Hills, CA 91367
(213) 887-4900

Versatec L
2710 Walsh Ave.
Santa Clara, CA 95051

Visual Systems Corporation D
3000 Town Center, Ste 3204
Southfield, MI 48075
(313) 354-1100

Wang Laboratories, Inc. L
Office Information Systems
7901 East Belleview Ave.
1st Floor
Englewood, CO 80110
(303) 771-3300

Xidex D
305 Soquel Way
Sunnyvale, CA 94086
(800) 538-1584

3M D
Micrographic Products Division
3M Center
St. Paul, MN 55101
(612) 733-1110

APPENDIX C

MATERIALS RELATED TO LEGAL ISSUES WITH DIGITAL IMAGE TECHNOLOGY

Federal Rules of Evidence

Subsection 6 of Rule 803 provides as follows:

(6) *Records of regularly conducted business activity.* A memorandum, report, record, or data compilation, in any form, of acts, events, conditions, opinions, or diagnoses, made at or near the time by, or from information transmitted by, a person with knowledge, if kept in the course of a regularly conducted business activity, and if it was the regular practice of that business activity to make the memorandum, report, record, or data compilation, all as shown by the testimony of the custodian or other qualified witness, unless the source of information or the method or circumstances of preparation indicate lack of trustworthiness. The term "business" as used in this paragraph includes business, institution, association, profession, occupation, and calling of every kind, whether or not conducted for profit.

Federal Version of the Uniform Photographic Copies of Business and Public Records Act.

§ 1732. Record made in regular course of business; photographic copies

If any business, institution, member of a profession or calling, or any department or agency of government, in the regular course of business or activity has kept or recorded any memorandum, writing, entry, print, representation or combination thereof, of any act, transaction, occurrence, or event, and in the regular course of business has caused any or all of the same to be recorded, copied, or reproduced by any photographic, photostatic, microfilm, micro-card, miniature photographic, or other process which accurately reproduces or forms a durable medium for so reproducing the original, the original may be destroyed in the regular course of business unless its preservation is required by law. Such reproduction, when satisfactorily identified, is as admissible in evidence as the original itself in any judicial or administrative proceeding whether the original is in existence or not and an enlargement or facsimile of such reproduction is likewise admissible in evidence if the original reproduction is in existence and available for inspection under direction of court. The introduction of a reproduced record, enlargement, or facsimile does not preclude admission of the original. This subsection shall not be construed to exclude from evidence any document or copy thereof which is otherwise admissible under the rules of evidence.

(June 25, 1948, ch. 646, 62 Stat. 945; Aug. 28, 1951, ch. 351, §§ 1, 3, 65 Stat. 206; Aug. 30, 1961, Pub. L. 87-183, 75 Stat. 413; Jan. 2, 1975, Pub. L. 93-595, § 2(b), 88 Stat. 1949.)

1–10. Legal status. Microfilm will be produced so as to meet the requirements for admission as evidence in a Federal Court. Legal status of microfilmed documents and information is contained in 28 U.S.C. 1732 and 44 U.S.C. 2112.

a. Federal statutes provide for the legality and admissibility as evidence of records made by "any photographic, photostatic, microfilm, microcard, miniature photographic, or other process which accurately reproduces or forms a durable medium for so reproducing the original."

b. To be legally acceptable, such microforms must be produced either in the regular course of business, or in accordance with the Federal Property Management Regulations (FPMR) Subpart 101–11.5.

c. Forgeries generally cannot be proven from microforms. Legal advice will be obtained prior to disposal of documents having legal significance, if their authenticity is likely to be questioned.

d. Legal coordination will be obtained at the local level prior to submission of a MICRODIS request.

1–11. Archival Microfilm. Only silver halide microfilm is currently of sufficient archival quality to be substituted for hard copy documents, records, or information requiring extended retention, or for producing microforms of permanent retention value.

a. An archival film test to determine the residual thiosulfate concentration of processed silver halide film is required for all microfilmed records that are expected to be retained 10 years or longer.

b. All archival film testing will be performed in accordance with American National Standards Institute (ANSI) Standard PH 4.8–1971 (methylene blue technique).

c. Samples of properly identified, processed film will be forwarded for testing in accordance with DA Form 4488, Archival Film Test Transmittal. Copies of this form are available from HQDA (DAAG-AMS–M), WASH DC 20314.

d. Organizations having access to test facilities may forward results of tests in lieu of film samples. Use DA Form 4642, Archival Film Test Report, for this purpose. Copies of this form are available from HQDA(DAAG–AMS–M), WASH DC 20314.

1–12. Micrographics standardization. *a.* The use of microforms in the recording and dissemination of documents and information is widespread in the Federal Government, and the volume is steadily increasing. Uniformity of microform formats and reduction ratios is required in order to enhance the exchange and utilization of information in microform, and to provide compatibility of user equipment. It is therefore essential that the number of different microforms and reduction ratios be kept to a minimum. All microforms created by or for the Department of the Army must conform to one of the formats specified in MIL–STD–399–A.

b. Deviations from, and exceptions to, standard microform formats require TAG approval, and will be forwarded to HQDA as part of the MICRODIS request (DA Form 1500–R).

1–13. Classification and protective markings.

a. Security markings and/or protective markings will meet the requirements of DOD Regulation 5200.1 and DOD Regulation 5400.7, AR 380–5, and AR 340–16.

b. Aperture cards will be marked in accordance with MIL STD 804.

c. Roll microfilm will be marked in accordance with MIL–M–46849.

d. Microfiche will be marked in accordance with MIL–M–38748 and MIL–M–63048.

e. Regrading instructions may be abbreviatd in accordance with DOD 5200.1–R, within the header area of microfiche and at both ends of a roll of microfilm. Header area lettering must be readable without magnification.

f. One frame at the beginning and end of each microfilm roll, or in the beginning frames of a microfiche, will bear the complete classification

APPENDIX D

ASSUMPTIONS USED IN COST ESTIMATES

Appendix D.1 Assumptions Used for System Activity Calculations in Report Unless Otherwise Indicated

Volume:	100,000 records	
Images:		
Record:	75 (2 fiche)	
P-fiche:	50 (1 fiche)	
Total:	7.5 million	
Updates:		
Accession:	20 pages	1 time
Annual:	2.5 pages avg.	4 times/year
Board Review:	5000 records required	
Duplication:	2000/day 500,000/year	
Filming:	4000 images/day 1 million images/year	
Accessions/ Discharges:	10,000/year	

Appendix D.2 Assumptions Used in Report for Production Rates (per minute)

		Unit	Existing System	ADSTAR+ DIT	Digital Image System
1.	Document Preparation/Screening				
	a. Accessions	Record (20 pages)	.75	.75	.75
	b. Updates	Document (15 pages)	6.0	6.0	6.0
	c. Requests	Number	3.0	3.0	3.0
2.	Indexing/Computer Inquiry	Record	1.5	1.0	1.0
		Document		2.0/ 4.0*	2.0/ 4.0*
3.	Sorting	Document	6.0	--	--
4.	Filing/Retrieval of Documents for Filming	Document	6.0	--	--
5.	Retrieval of Master Microfiche	Microfiche	2.5	--	--
6.	Pre-Inspection	Microfiche	3.0		
7.	Filming/Scanning	Image	2.5	6.7	30.0
8.	Post-Inspection/ Image Enhancement	Image	6.0	16.0	--
	(Required for 25% of images)	Image	--	--	16.0
9.	Compile Record	Record	0	.12	1.71
	Image	(50 pages)	--	6	100
10.	Microfiche Duplication	Microfiche			
	a. Staff Time	(50 pages)	1.75	--	--
	b. Machine Time			1.0	1.0
11.	Filing of Master	Microfiche	2.5	--	--
12.	Destruction of Documents	Documents	--	--	--

*Rate applies for over 4 images for same record.

Appendix D.3 Assumptions Used in Report for Production Rates by Application (units per minute)

	Existing System	ADSTAR+ DIT	Digital Image System
A. Accessions (Unit = 1 accession record consisting of 20 images or 13.3 documents.)			
1. Document Preparation/Screening	.75	.75	.75
2. Indexing/Computer Inquiry			
a. Record	1.5	1.0	1.0
b. Image (133 documents)	--	.3	.3
3. Microfiche Retrieval	--	--	--
4. Pre-Inspection	--	--	--
5. Filming/Scanning	.125	.335	1.5
6. Post-Inspection/ Enhancement	.3 --	.8 --	-- .8
7. Microfiche Refiling	2.5	--	--
Effective Rate/Accession	.07	.10	.13
B. Updates (Unit = 1 document containing 1.5 images)			
1. Document Preparation/Screening	6.0	6.0	6.0
2. Indexing/Computer Inquiry	1.5	2.0	2.0
3. Sorting	6.0	--	--
4. Filing/Retrieval of Documents for Filming	6.0	--	--
5. Retrieval of Microfiche	2.5	--	--
6. Pre-Inspection	3.0	--	--
7. Filming/Scanning	1.67	4.47	20.0

	Existing System	ADSTAR+ DIT	Digital Image System
B. Updates (continued)			
8. Post-Inspection/	4.0	10.67	--
Enhancement	--	--	10.67
9. Duplication	1.75	--	--
10. Refiling of Microfiche Master	2.5	--	--
Effective Rate/Documents for Filming	.27	1.02	1.23
C. Requests (Unit = 1 microfiche consisting of 50 pages)			
1. Request Processing	3.0	3.0	3.0
2. Retrieval of Microfiche/Images	2.5	--/.12**	--/1.71**
3. Duplication	1.75	--/1.0**	--/1.0**
4. Refiling of Master Microfiche	2.5	--/--	--/--
Effective Staff Rate/Request	.28	3.0	3.0
**Effective Machine Rate/Request	--	.11	.63
Effective Total Rate/Request	.28	.11	.52
**Machine Time - no staff time required.			
D. Separations (Unit = 1 MPRJ and Master Microfiche)	.2	.2	.2
E. Conversion (Unit = 1 microfiche containing 75 images)			
1. Retrieval of Master Microfiche	--	2.5	2.5
2. Scanning	--	.089	.4
3. Indexing: Record	--	1.0	1.0
Images		.05	.05
4. Post-Inspection/	--	.21	--
Enhancement	--	--	.21
5. Refiling of Master Microfiche	--	2.5	2.5
Effective Rate/Microfiche Converted		.026	.034

Appendix D.4 Assumptions Used in Report for Cost Estimates for Digital Image Technology (Staff requirements by site)

Assumption: Day = 6.5 hours
Year = 240 working days

		MILPERCEN	EREC	RCPAC	National Guard
1.	Annual Volume				
a.	Accessions	10,000	145,000	35,500 (Reserve) 160,000 (Other)	5,000
b.	Updates (Documents for Filing)	380,000	3,300,000	754,000	190,000
c.	Requests	300,000	350,000	175,000	150,000
d.	Separations	10,000	152,000	100,000	5,000
e.	Conversion (Microfiche Records in System)	102,000	675,000	360,000	47,000
2.	Conversion Requirements				
a.	Document Preparation Clerk				
	1. Production Rate (Units/Min.)	1.25	1.25	1.25	1.25
	2. Staff Required	.87	5.76	3.08	.40
b.	Scanner Operator				
	1. Production Rate (Units/Min.)	.4	.4	.4	.4
	2. Staff Required	2.72	18.0	9.62	1.26
c.	Data Entry Operator				
	1. Production Rate (Units/Min.)	.048	.048	.048	.048
	2. Staff Required	22.70	150.30	80.13	10.46

	MILPERCEN	EREC	RCPAC	National Guard
d. Image Enhancement Operator				
1. Production Rate (Units/Min.)	.21	.21	.21	.21
2. Staff Required	5.19	34.34	18.32	2.39
3. Operational Requirements				
a. Document Preparation Clerk				
1. Production Rates (Units/Min.)				
- Accessions	0.75	0.75	0.75	0.75
- Updates	6.0	6.0	6.0	6.0
- Requests	3.0	3.0	3.0	3.0
- Separations	0.2	0.2	0.2	0.2
2. Staff Required				
- Accessions	0.14	2.07	2.85	.06
- Updates	0.68	5.88	2.74	0.34
- Requests	1.07	1.25	0.62	0.53
- Separations	.53	8.12	5.34	.27
Total	2.42	17.32	11.55	1.20
b. Scanner Operator				
1. Production Rates (Units/Min.)				
- Accessions	1.5	1.5	1.5	1.5
- Updates	20.0	20.0	20.0	20.0
2. Staff Required				
- Accessions	.07	.92	.25	.04
- Updates	.10	.88	.40	.05
Total	.17	1.80	.65	.09
c. Data Entry Operator				
1. Production Rates (Units/Min.)				
- Accessions	.23	.23	.23	.23
- Updates	2.0	2.0	2.0	2.0
2. Staff Required				
- Accessions	.47	5.99	1.65	.23
- Updates	2.03	17.63	4.03	1.01
Total	2.50	23.62	5.68	1.24

	MILPERCEN	EREC	RCPAC	National Guard
d. Image Enhancement Operator				
1. Production Rates (Units/min.)				
- Accessions	.8	.8	.8	.8
- Updates	10.67	10.67	10.67	10.67
2. Staff Required				
- Accessions	0.13	1.72	0.47	0.07
- Updates	0.38	3.30	.75	0.19
Total	0.61	5.02	1.32	0.26

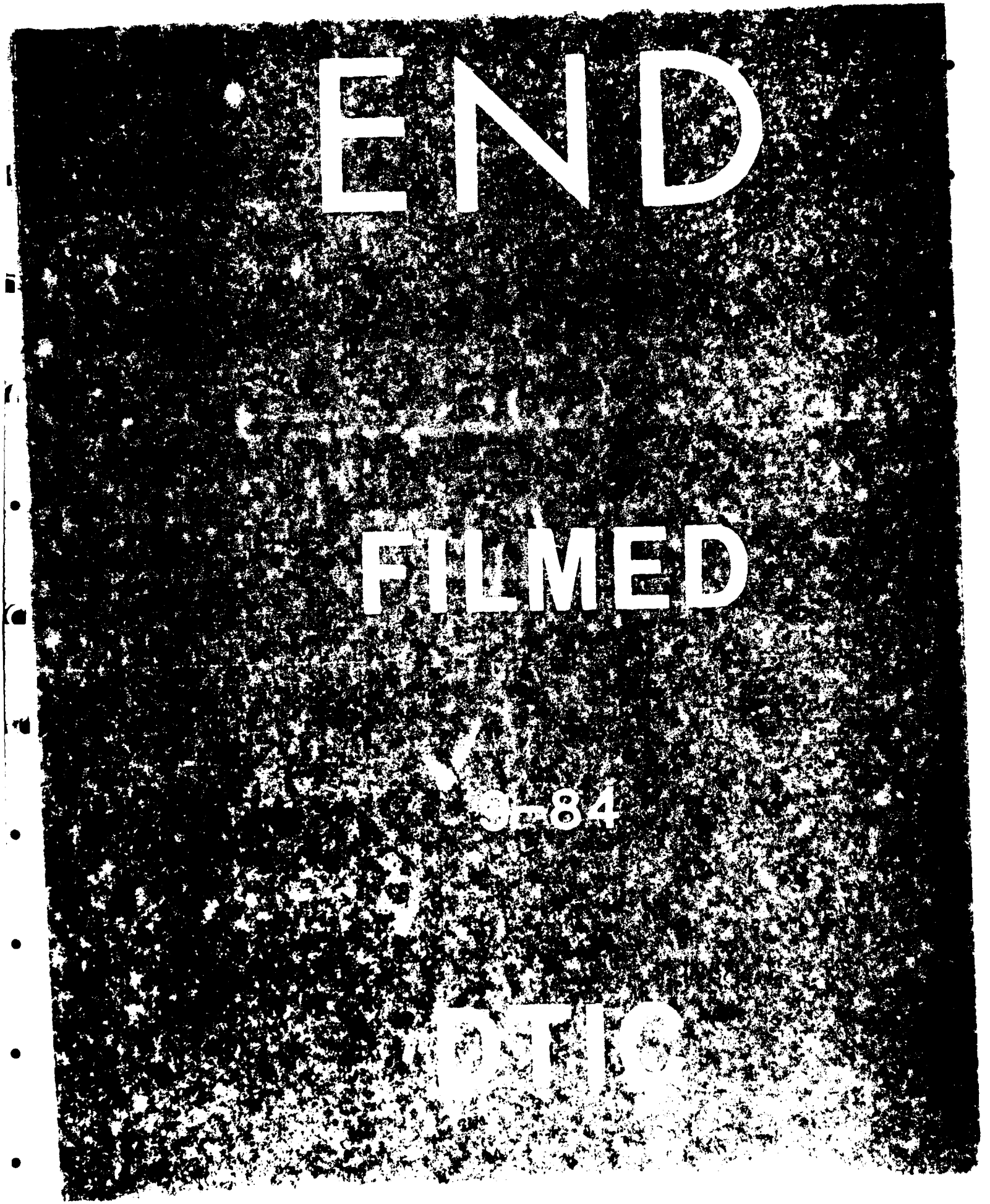
APPENDIX E

DATA AND RESPONSES FROM QUESTIONNAIRES

Appendix E. Summary of Values Used in System Evaluation and Comparison of Alternative Technologies.

System Selection Criteria	Weight	Current System	ADSTAR+ DIT	Digital Image
Image Quality				
a. Readable image	4.67	3.00	3.00	3.00
b. Ability to delete error/image	5.00	1.25	5.00	5.00
c. Ability to resequence images	4.67	1.50	5.00	5.00
d. Ability to enhance poor images	5.00	1.50	1.50	5.00
e. Acceptable reproduction of photo	4.00	1.50	1.00	4.00
Security				
a. Backup for data and images	4.67	4.00	4.00	4.00
b. Restricted access to information	4.67	2.25	5.00	5.00
Integrity				
a. Ability to retain image 75 years	4.00	1.67	5.00	4.00
b. Safeguards to prevent lost info.	4.33	2.50	5.00	4.00
Reliability/Maintenance				
a. Reliability of system	4.60	3.33	3.00	3.00
b. Responsive vendor support and maintenance	4.00	4.00	4.00	3.00
Image Creation/Management				
a. Rapid image capture	3.67	2.33	3.00	5.00
b. Rapid information retrieval	4.30	2.00	3.00	5.00
c. Ease of updating record	4.00	3.67	3.00	4.00
d. Ease of retrieving information	4.67	2.33	4.00	5.00
e. Ease of indexing	3.50	3.33	2.00	3.00
f. Ease of making backup	4.00	1.33	4.00	4.00
g. Minimal filing/handling of record	2.30	2.00	4.00	4.00
h. Potential to reduce human errors	4.00	3.33	4.00	4.00
i. Minimal human intervention	4.00	2.33	4.00	5.00

System Selection Criteria	Weight	Raw Scores Current System	ADSTAR+ DIT	Digital Image
System Development				
a. Use of proven technology	3.33	2.67	4.00	1.00
b. Flexibility to develop new systems	4.00	2.33	3.00	5.00
c. Minimal disruption of current system during conversion	3.67	2.50	2.00	4.00
d. Potential for paperless office	3.67	4.33	4.00	5.00
e. Potential for automatic extraction of data from images	4.00	2.50	1.00	4.00
Dissemination/Use				
a. Rapid transmission of images between sites	3.00	1.33	3.00	5.00
b. Rapid access to images by users	3.67	2.33	3.00	5.00
c. Ability to retrieve images while record is being updated	4.00	1.33	5.00	4.00
Personnel				
a. Minimal staff size	2.67	2.33	3.00	5.00
b. Minimal staff training	3.33	3.33	3.00	2.00
c. High job satisfaction	2.67	2.33	3.00	4.00
Cost				
a. Low system conversion cost	2.67	2.33	3.00	2.00
b. Low system operating cost	2.60	2.33	3.00	5.00
Environment				
a. Minimal space requirements	2.33	2.67	4.00	5.00
b. Minimal noise level	2.00	2.50	4.00	4.00
c. Comfort of working environment	2.33	3.25	4.00	4.00


END
FILMED
DTIC